WORLD OIL

SPECIAL REPORT: B
Four Corners Area
Page 26

Advance Planning and Equipment Unitization Speed Up Rig Move
Page 77

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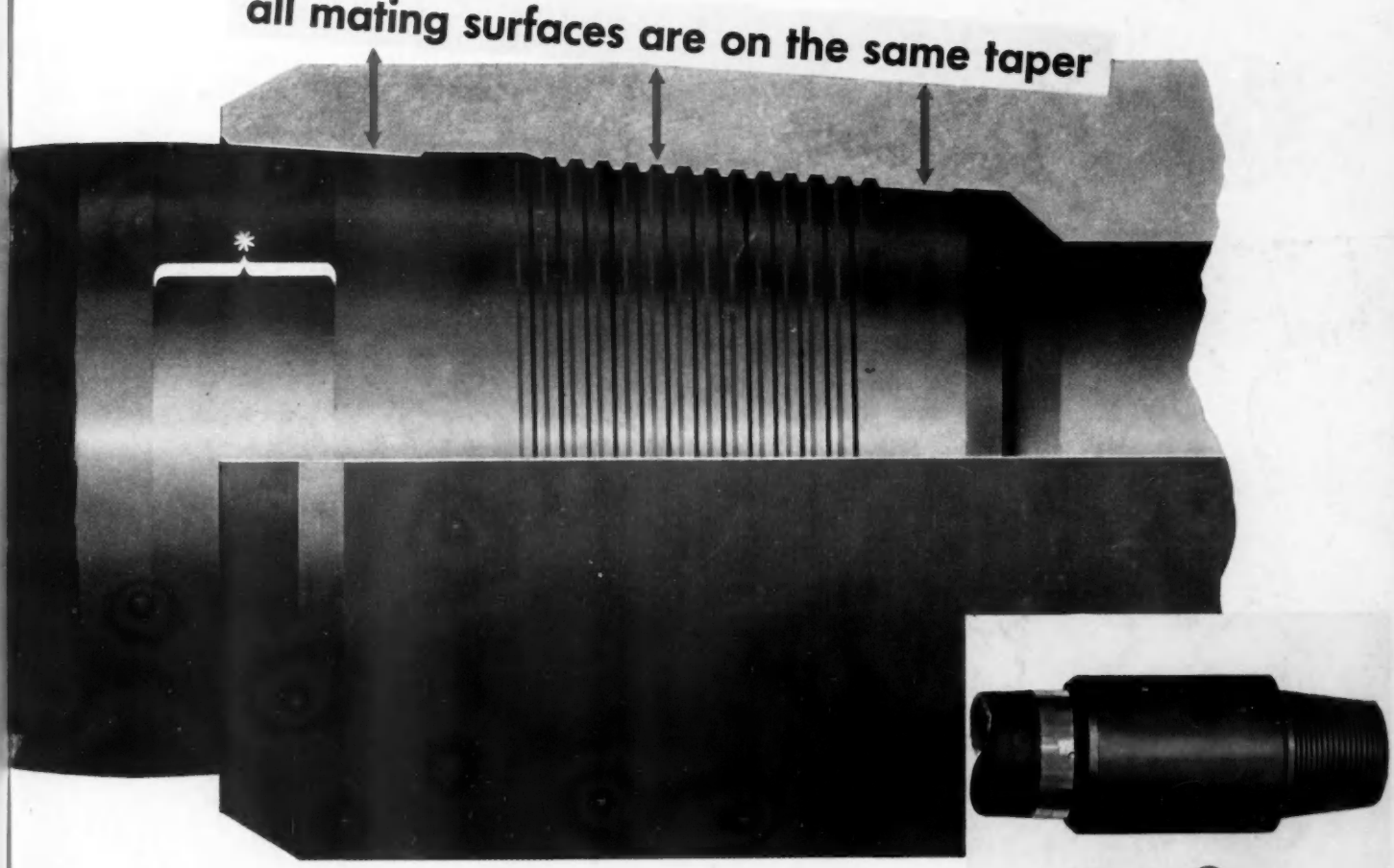

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Volume 145, No. 2 August 1, 1957

WORLD OIL

Established 1916 as The OIL WEEKLY

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a quick look at WORLD OIL this month

BUSY OIL MEN: To help you put first things first, scan these time-saving digests on this and the following pages, checking ☑ those you want to read first.

CURRENT OUTLOOK

☐ **This is a report** few people outside the oil industry will ever hear about. It is a story of oil industry contributions during Hurricane Audrey. It tells of the company helicopter pilot who went 52 hours with only seven hours sleep, risking his life many times as he directed rescue operations. Also, the silk screen technician who accomplished the gruesome task of directing a search that resulted in the recovery of 115 bodies. For these and many other examples of individual and group heroism during the disaster, plus a detailed description of what the companies did in furnishing equipment, fuel and money. **Oil and Hurricane Audrey . . Page 50**

☐ **Imports must be reduced** if the problem of U. S. surplus oil supplies is to be solved. That's the conclusion reached by this month's **Report from the Observatory (Page 56).** Meanwhile a survey made by the Suez Canal Company indicates traffic in the waterway will increase five-fold (particularly for oil) in next 15 years. (See **Looking Ahead, Page 19**) In Canada, new gas lines are encouraging exploration and development drilling. And back in U. S., the IPA and AAODC are taking long looks at increased operating costs (**Page 19**).

EXPLORATION

☐ **Destined perhaps to become one** of the nation's most prolific oil reserves is the relatively undeveloped Delaware Basin in West Texas and southeastern New Mexico. A geological appraisal of the area as well as data on present production and future prospects are discussed on **Page 68. Delaware Basin—The Next Big Boom? . . . . . C. E. Barnes and E. W. Caldwell**

Turn the Page ▸

THIS MONTH . . .

A Special Report from the

☐ **Development in Four Corners area** of the Rocky Mountain region promises to become the biggest onshore oil play of the decade. Drilling and exploratory activities around this common corner of Utah, Colorado, New Mexico, and Arizona have been greatly stimulated by the definite prospects of pipe line outlets for crude oil production. Work already is under way on a 750 mile crude oil pipe line from Aneth, Utah, to Los Angeles. Two other crude lines also have been planned. Gas pipe lines already provide market for natural gas production. Over 100 drilling rigs are running in the Paradox and San Juan basins, nearly double the number operating a year ago. Twenty-one companies reported a total of 41 seismic crews at work in the Four Corners area in late June. **High Potential Paradox Discoveries, Expanding Bisti Trend Spur Development. Tom Dougherty**.....**See Page 26**

☐ **Pipe Lines Brighten Outlook.** Development in the Four Corners area has been encouraged greatly by plans for construction of several crude oil pipe line outlets. Construction is under way on Four Corners Pipe Line Company's 750-mile system leading to Los Angeles. Surveying has begun on a 515-mile extension of Texas-New Mexico Pipe Line Company's system from Jal, N. M., to Aneth area. Northwest Pipe Line Corporation proposes to build a 500-mile line from the San Juan Basin to Salt Lake City. **New Crude Lines in Offing**.....**Page 30**

☐ **Water Scarce, Transportation Difficult.** Adding to drilling problems in the Four Corners area are lack of water, and terrain that at times defies transportation. Almost inaccessible locations raise the problems of keeping rigs supplied with fuel and moving supplies over bad roads. Any operator mulling over a move into the area will want to find out how these problems are being solved. See **Page 32. Transportation and Water Scarcity Pose Drilling Problems**..... **Marvin T. Parker**

☐ **Staking well locations and locating access roads** often run into great expense in the Four Corners area. These costs sometimes amount to as

DRILLING ARTICLES

☐ **Trim time and weight from the transportation of a rig** with these tips for the drilling contractor. One contractor has devoted considerable time to studying rig moves. Here is a picture story to show how a diesel-electric rig with unitized equipment and plenty of advance planning was moved and spudded-in in record time. Turn to **Page 77. Organization and Planning Speed Rig Moves**.....**John N. Schuelke**

☐ **A unique method of separating** gas and cuttings in the return line allowing the resale of the gas has provided a considerable saving to the Magnolia Petroleum Company in their drill-deeper operations in the Spraberry field of West Texas. For a description of this operation and the separating device used turn to **Page 82. Gas Drilling Reduces Drill-Deeper Costs . . . C. H. Sample, G. S. Young** and **D. G. Marrs**

☐ **An easy to follow basic description** of the characteristics of the series and shunt generator and motor and the various control devices used to control their speed and torque is presented on **Page 84. Electric Power Transmission for Drilling Rigs (Part 2) —Generators, Motors and Controls**....**Glen W. Webb**

☐ **Power requirements and hole problems** are discussed (**Page 90**) in the second and concluding part of **Two Years of Air Drilling Evaluated**.....**Lt. Comdr. Jerome A. Rehberg**

PRODUCTION ARTICLES

☐ **A new process being introduced** to the industry to control stress patterns and the line of horizontal fracture has been developed, and tested in 52 field applications. This article describes the process with its capabilities, limitations and restricted uses. Controlling the point of initiation and fracture development in a uniform plane is advantageous on many zones where fracturing is applicable. **New Process Controls Horizontal Fracturing**.....**Page 103**

☐ **Strain complications out of your gas lift** installation designs with this graph system. It reduces hours of work to minutes and provides a high

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Four Corners Area . . .

much as the total cost of drilling a well. This is particularly true in the Paradox Basin. Typical costs are estimated and the problems involved are discussed in the story beginning on **Page 40. Building Roads, Staking Locations Are Important Cost Factors. . . J. P. Leese**

☐ **A sand play is developing** around the rim of the San Juan Basin gas-producing area. This activity is prompted by a recent string of high gravity crude oil discoveries, the Bisti field being the largest so far. This article discusses general geology and some of the more significant aspects of this important play. Included are occurrences, depths, drillings costs, expected recoveries, and crude outlets. Completion of new pipe line outlets this fall should encourage even greater activity along this trend play. See **Page 45. Activity in San Juan Basin Rim Area. . . . . Harrell Budd**

☐ **The Paradox Basin,** one of the most important new producing areas found in the U. S. in recent years, is reviewed in this issue. Discussed are some of the 28 known structures of the basin, including the amount of closure, formation pressures, permeability, initial production, gas-oil ratios, and results of significant tests for each of them. You will also find on these pages a brief picture of the over-all stratigraphic structural conditions within this 350-mile long and 175-mile wide basin in the northwest part of the booming Four Corners area. You'll want to clip and file this article for future reference. Turn to **Page 63. Structures of the Southwest Paradox Basin. . . . . Marvin L. Matheny**

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degree of accuracy. For a series of articles that has a place in your production file see **Page 106. "Graph System" Gives Gas Lift a Lift. . . . . E. D. McMurry**

☐ **Separators—Heaters—Treaters.** What do these things mean to you? What are their functions? How do they operate? Is your installation efficient? An explanation of these units, and others, along with their contributions to gravity conservation is given from an operational viewpoint on **Page 116. Gravity Conservation (Part 2). . . . . Lawton L. Laurence** and **Walter E. Huffman**

☐ **One of the world's largest conservation** plants, designed to inject 300 million cubic feet of gas daily, was recently completed by Creole Petroleum as part of its Venezuela conservation program. The platform, in 85 feet of water, lies seven miles offshore from Tia Juana in Lake Maracaibo and is the second injection plant in the lake. The $28 million plant is powered by 12 turbine and centrifugal compressors with a total horsepower of 96,000. **Creole Advances Venezuela Conservation Program. . . . . Page 132**

INTERNATIONAL ARTICLES

☐ **Tremendous strides are being made** in the use and conservation of natural gas in Venezuela. Three times more natural gas was used in 1956 than in 1946, and this will increase substantially in the next few years. However, of greater importance is the progress made in gas conservation. Twenty-three times more natural gas was returned to producing formations during 1956 than ten years ago. Gas reinjection will show further very large growth during 1957. See **Page 139. Venezuela Conserves Gas and Increases Oil Recovery. Warren L. Baker**

☐ **Bolivian Gulf Oil Company will test** concession acreage allotted under terms of the new oil law to the Yacimientos Petroliferos Fiscales Bolivianos, the state oil agency. Domestic crude production rises to 8000 barrels per day. Increased drilling activity at Buena Vista and Itapirenda scheduled. For the significance of this renewed interest in Bolivian oil and what the prospects are likely to be for the future, see **Page**

Turn the Page ▸

142 for the second part of a two-part evaluation of the Bolivian oil industry. **Bolivian Gulf Wildcat To Test YPFB Concession Acreage**.....**Dr. Enrique T. Mauri**

☐ **What would drilling conditions be like** in the 130° F. temperature of the North African desert? Unbearable? Camdrill International thought so too so they have air-conditioned their large 12,000-foot rig to bring the temperature on the rig floor down to a comfortable 80° F. For more on this unique set-up see **Page 153. "Air Condition Your Rig"**.....**John N. Schuelke**

Near Record U. S. Drilling Expected in Last Half of 1957

A substantial increase in oil drilling activity during the remainder of 1957 in the U. S. is expected to offset the reduced level record during the first half of the year. A paralleling gain in new producing well completions also is anticipated.

This forecast is based on WORLD OIL's annual midyear survey of probable drilling volumes not only for the U. S. but also for the entire world, and it is one of the articles which will be featured in the August 15 International Outlook Issue. In addition to complete facts and figures on oil industry operations outside the U. S., this special issue also will contain authoritative reports on all other phases of the U. S. oil business—from exploration to imports.

The long-range outlook for U. S. drilling is equally as bright as the prospects for the remainder of this year.

Drilling Rates Rising

WORLD OIL's drilling forecast for the second six months of 1957 indicates U. S. levels of operation almost equal to the second-half record experienced during 1955. The second half of the year is expected to furnish 29,594 well completions—13.5 percent more wells than were completed during the first half of the year.

Substantial increases also are boosting 1957 drilling operations to new peaks in Western Canada and Venezuela. Data for these and all other countries in which even a single well was spudded in last year will be presented in the International Outlook Issue.

Issue to Feature Maps

Complete with a colored map insert of the burgeoning Prairie Provinces of Western Canada, a large oil field map of Venezuela and numerous maps showing oil areas of interest in other parts of the world, the August 15 issue will contain Special Reports on Africa, Western Europe, the future of Middle East oil, and Iron Curtain countries. And, of course, Venezuela and Canada.

International Outlook Issue to be published August 15

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Indexed by Industrial Arts Index and Engineering Index

WHO'S MEETING WHERE

AUG.	
1– 3	Third Annual Rocky Mountain Mineral Law Institute, Montana State University Law School, Missoula, Mont.
21–24	Rocky Mountain Association of Geologists, Annual Field Trip, North and Middle Park Areas, Colorado.
SEPT.	
5– 7	New Mexico Geological Society, Eighth Annual Field Conference, Durango-Silverton-Ouray Area of Southwestern Colorado.
11–13	National Petroleum Association, 55th Annual Meeting, Atlantic City, N.J., Traymore Hotel.
12–14	Wyoming Geological Association, 12th Annual Field Conference, Southwestern Wind River Basin, Headquarters, Lander, Wyo.
13–14	Ardmore Geological Society, Two-day Field Trip, Carter and Love Counties, Oklahoma.
26–27	Mid-Continent Oil & Gas Association, Louisiana-Arkansas Division, Annual Membership Meeting, New Orleans, Roosevelt Hotel.
OCT.	
1– 2	Texas Mid-Continent Oil & Gas Association, 38th Annual Meeting, Texas Hotel, Fort Worth.
1– 4	National Association of Corrosion Engineers, South Central Region, Municipal Auditorium, Oklahoma City.
5– 8	National Association of Corrosion Engineers, Northeast Region, Hotel Somerset, Boston.
6– 9	AIME, Petroleum Branch, 32nd Annual Fall Meeting, Adoo, Adolphus, Baker & Statler-Hilton Hotels, Dallas.
7–Nov. 15	School of Production Technology, Fall Term, Kilgore College, Kilgore, Texas.
7– 9	American Gas Association, Annual Convention, Kiel Auditorium, St. Louis.
13–15	American Association of Oil Well Drilling Contractors, 17th Annual Meeting, Mayo Hotel, Tulsa.
18–19	Symposium, "Legal Problems in the Tidelands," Dixon Hall Auditorium, Tulane Campus, Tulane University, New Orleans.
23–25	National Association of Corrosion Engineers, Seventh Biennial Permian Basin Corrosion Tour, Odessa-Midland Area.
27–29	Independent Petroleum Association of America, Annual Membership Meeting, Statler-Hilton Hotel, Dallas.
31–Nov. 1	AAPG Mid-Continent Regional Meeting, Cimarron Ballroom, Tulsa.
NOV.	
6– 8	Gulf Coast Association of Geological Societies, 7th Annual Convention, Roosevelt Hotel, New Orleans.
11–14	API 37th Annual Meeting, Conrad Hilton Hotel & Palmer House, Chicago.
DEC.	
5– 6	API Oil Information Committee Meeting, Biltmore Hotel, New York City.

Nomads' Chapter monthly meeting: Los Angeles, second Wednesday, Jonathan Club, Wallace A. Sawdon, Secretary. Houston, second Monday, Ye Old College Inn, Harry E. Estes, Secretary. Dallas-Fort Worth, first Monday, Greater Dallas Club, Hank Davis, Secretary. Tulsa, Hotel Tulsa, Gilbert Swift, Secretary. New York, first Monday, Hotel Biltmore, Jesse E. Hickman, Secretary.

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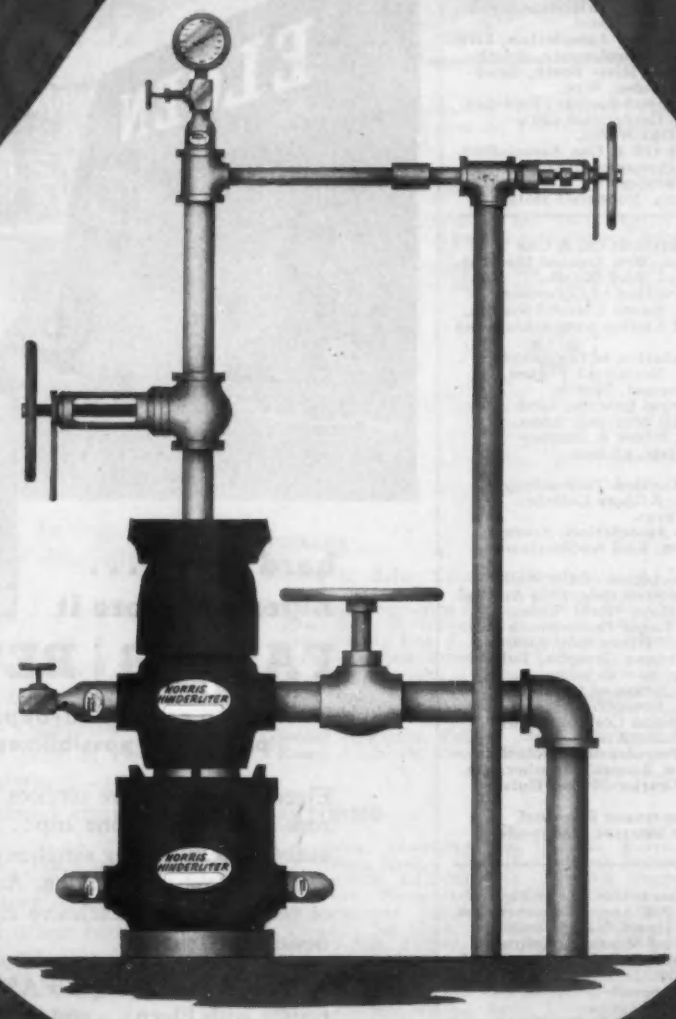

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Looking Ahead . . .

Crude Demand to Be Off Further in August . . . Demand for domestic crude oil will show further shrinkage in August. U. S. Bureau of Mines estimated demand for Texas crude at 2.7 million barrels daily in August, 175,000 barrels less than its July forecast and 375,000 less than its June estimate. The Texas Railroad Commission ordered only 13 producing days in Texas fields in August, the same low number as in July. Buyers' requests for Texas crude in August had been 86,270 barrels daily below July. From its March peak, the Texas crude production allowable had been cut lower each month in April, May, June, and July.

Crude Raise Needed to Cover Higher Costs . . . An increase of 5 cents per barrel in crude prices is needed to cover recent increases in industry costs, said Robert L. Wood, Midland, Texas, president of Independent Petroleum Association. Recent steel price increases will cost the industry $36 million and raise the cost of producing oil one cent per barrel, he calculated. And the recent $100 million annual wage increase in the oil producing industry added 3¾ cents to the cost of producing a barrel of oil. Wood commended recent gasoline price increases made to cover wage hikes. He said the same policy for crude oil is equally justified.

Contractors Urged to Allow for Costlier Steel . . . Drilling contractors have been urged to take into consideration the recent steel price increases in their future bidding. This advice was given by C. H. Todd, chairman of the accounting committee of the American Association of Oilwell Drilling Contractors. Drilling contractors have been operating on a narrow profit margin for years, said Todd, and have been constantly absorbing various phases of increased drilling costs. The most recent increase follows several previous increases during the past two years, Todd stated, and is the second in 1957.

Big Increase Seen for Suez Canal Traffic . . . The potential growth of Suez Canal traffic—particularly for oil—in the next 15 years is expected to be a five-fold increase over 1955, according to a study made by Ebasco Services, Inc., for the Suez Canal Co. Most of the increase would go to Europe. Ebasco estimates that the 1955 total of 56.2-million metric tons will jump to almost 300-million tons in 1972. The flow to North America will also increase, but not so rapidly.

The report takes into account a possible substantial increase in pipe line transportation of Middle East oil. The combined westward movement from the two producing regions by pipe line would increase from 40.2-million tons in 1955 to 70.6-million in 1964 and to 117.5-million in 1972. The report recognizes the trend to larger tankers, but does not appear to feel this will cut deeply into Suez Canal traffic.

New Gas Lines Will Boost Canadian Drilling . . . A brisk increase in gas exploration and development drilling will occur in western Canada when gas starts moving to market through the two major pipe lines, one going west, one east, which now are under construction. Markets for gas will mean re-opening of many capped wells, step-out evaluation work around many idle one-well gas finds, plus a sustained, long-term effort aimed at finding new reserves.

The Fort St. John—Peace River gas area already is experiencing an upturn in activity in anticipation of the completion late this year of the Westcoast line to the Pacific Northwest. With stepped-up exploration for gas, new oil finds also are certain to be turned up.

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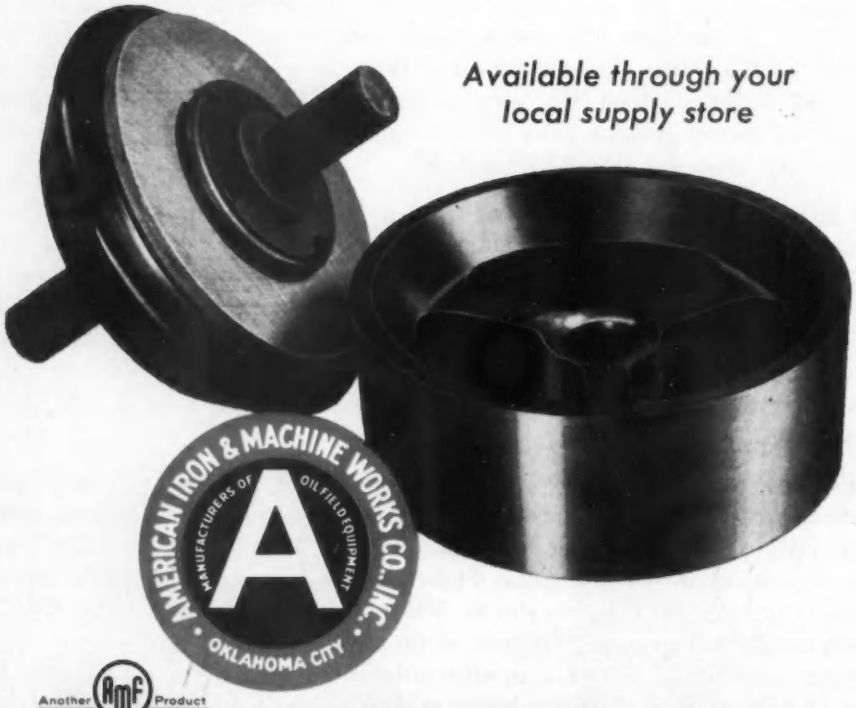

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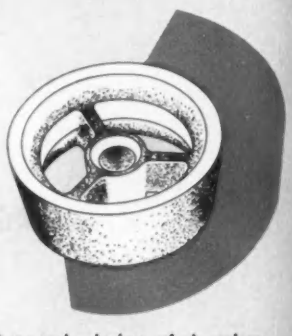
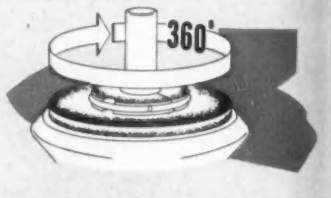
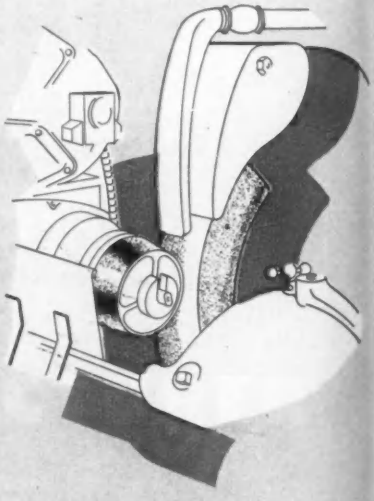


Three-web design of American Iron Valve Seats enables seats to absorb terrific pounding of modern high pressure pumps while providing maximum fluid passage.



Split-ring retainer is standard equipment. This retainer gives 360° support to insert, preventing chipping or cracking of rubber compound.



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Each American Iron Valve is treated with Lubrite. This chemical treatment guarantees rustless valves even in damp weather and over prolonged storage.

LOOKING AHEAD . . .

Powder River Basin Due for Big Play . . . A big play in the Powder River Basin of Wyoming is shaping up with the discovery of the Donkey Creek area in Crook County. The California Company has proved its Birch Creek unit in Sublette County with a gas-distillate well. Completions this year are ahead of a year ago, with 25 rigs on wildcats and 54 on development wells.

Pembina Completion Method Saves Money . . . Keep an eye on a new, experimental, low cost completion technique developed by a large operator in the marginal area of the huge Pembina field of Alberta. The technique represents a saving per well of about $25,000 over the conventional completion to the 4800-foot pay zone. It involves cementing of 7-inch surface pipe to 700 feet, drilling 6¼-inch hole, and diamond coring through the pay, to total depth.

Production string of 2⅞-inch O.D. EUE tubing is run to bottom and cemented in solid up to inside the 7-inch. Radioactive log is run, pipe is perforated, and well is fractured for either flowing production or completion on the pump. The idea has merit not only in marginal areas of Pembina but also in numerous other fields in Canada and U. S.

Wanted: More Efficient Pump Standards . . . Three top industrial organizations are combining efforts to introduce standards in pump manufacturing companies. One subcommittee found there are some 3000 different centrifugal pumps with capacities between 5 and 1000 gallons per minute. Group reports that between eight and ten standard centrifugal pumps could do the job.

New Marsh Vehicle Will Move Rig Over Muskeg . . . A major Canadian operator shortly will take delivery of an experimental model of a marsh vehicle large enough to transport a full size drilling rig across soft muskeg areas that prevail in northern Canada. Extensive testing of the vehicle will be conducted in muskeg terrain. It's just one more evidence of a determination on the part of Canadian operators to make drilling a more nearly year-around operation; not just a winter operation when the ground is frozen. Specially designed roads and drilling locations also are gradually overcoming muskeg area travel and operational problems.

Many People Have Stake in Oil . . . Many people throughout U. S. (and abroad) are stockholders in oil companies. They are a good nucleus around which to build good will for the industry. A recent tabulation showed that six oil companies were among the 20 U. S. companies having the greatest numbers of stockholders. The sum of their common stockholders was nearly 1.2 million, though some owners doubtless were counted among two or more of the six oil company stockholder families. The six oil companies were in order of number of stockholders, Standard Oil (N. J.), Socony Mobil, Cities Service, Standard (Indiana), Standard of California, The Texas Company.

Texas Purchaser Act Is Challenged . . . The Texas Supreme Court has been urged in friend-of-court brief filed by five independent producers' associations to uphold a Texas Railroad Commission order requiring ratable taking of natural gas. The commission declared Permian Basin Pipeline Company a common purchaser and ordered it to take gas ratably from all producers in the Puckett (Ellenburger) field, Pecos County, and to give producers equal access to its processing plant there. The order was the commission's first declaring a gas pipe line a common purchaser and requiring it to take gas ratably from all producers. The order was voided in lower court, upheld in appeals court and carried to Supreme Court. The suit challenges constitutionality of the Texas Common Purchaser Act.

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HUGH ROY CULLEN

Hugh Roy Cullen, Houston independent oil man and philanthropist, who died July 4, 1957, was a remarkable man, even in an age of remarkable and generous oil men.

Without formal education his alert and progressive mind employed every type of technical know-how in oil exploration with great success as his many philanthropies attest.

A staunch believer in the private enterprise system of American democracy, he was a man whose stand was never concealed and to the mind of this writer his position and his principles were sound. In the many years we knew him his integrity was never under question.

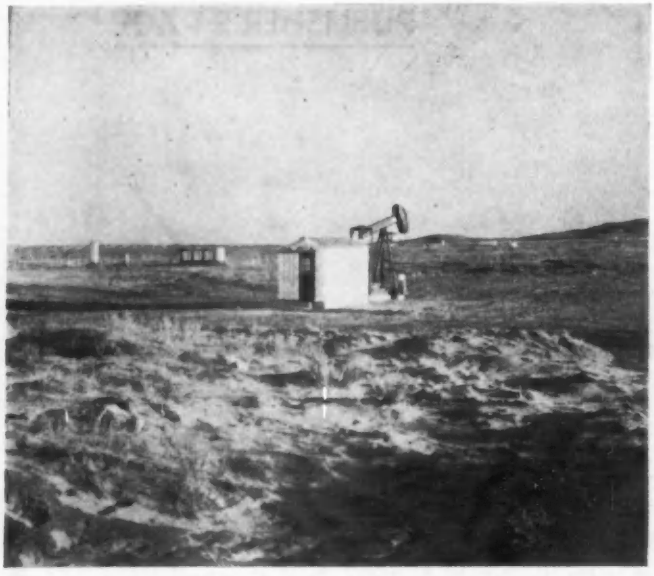
The extent of his philanthropies, in which he was joined and encouraged by his wife, Lillie Cranz Cullen, probably have been equalled by only one other oil man, John D. Rockefeller. His generosity was not confined to the University of Houston, with its enrollment of more than 13,000 for whose growth he was greatly responsible. Many hospitals, a medical college received millions from him—raising the health standards of an entire and numerous community. Nor were his philanthropies confined to Houston or Texas. Many colleges and universities in other areas were the beneficiaries of his success. And he did not wait until his death to give away by far the biggest part of his fortune.

He was a kindly man, a pleasant friend and neighbor—a man whose heart was always open for another generous act, big or small, which would help a worthy cause or unfortunate person.

We confess that his death brought tears to our eyes and a sense of loss which will not soon be dimmed.

Ray L. Dudley

Publisher, WORLD OIL



NEW MEXICO Here is a typical producing well and, in the distance, tanks and surface facilities in Bisti oil field of southwestern portion of San Juan Basin, New Mexico. Field produces from Gallup sand; is largest producing area thus far in gradually shaping oil trend along rim of gas producing area.

COLORADO In the distance is a drilling rig in the gas-producing area of the Colorado portion of the San Juan Basin. Thaw periods produce grease-like surfaces on some roads in this portion of the basin. Roads become almost impassable in such conditions, unless four-wheel drive vehicles and tractors are used.

High Potential Paradox Discoveries, Expanding Bisti Trend Spur Development

By TOM DOUGHERTY, Denver

ANETH is a trading post in the southeastern Utah portion of the Navajo Indian reservation. Few off the reservation had heard of it before last year.

Now, almost anyone in the domestic oil producing industry knows Aneth as one of the major oil fields found in the U. S. in the past several years.

Aneth field, biggest so far found in the Paradox Basin, is a concrete realization of the objectives of the exploratory program being conducted in what is more broadly known as the Four Corners area. That region embraces at least two Rocky Mountain basins. It promises the biggest onshore oil play of the decade.

How big Aneth is in terms of barrels of oil is a question not yet settled. Some say that this area of the Paradox Basin has between 10,000 and 30,000 barrels of recoverable oil per acre. Others are more conservative. Some give the southeastern Utah-northwestern New Mexico development of the past three years credit for uncovering some 100 million barrels of oil. Others claim reserves of 300 to 400 million barrels of Four Corners oil on the basis of what has been done to date.

No one can make a really reliable estimate now. The fields already developed can't produce more than their current 4000 or 5000 barrels per day in southeastern Utah, less in northern New Mexico because there is no way to move the oil to market.

New Pipe Line. But by spring of 1958 the 750-mile Four Corners pipe line to Southern California will be completed and ready to move 60,000 barrels per day from the newly developed fields of the area.

ARIZONA Indian trading post of Tes Nos Pas on Navajo Indian reservation in northeastern Arizona, a few miles southwest of Four Corners monument. Note typical terrain, geophysical vehicles, uranium truck (left). The numerous new pickup trucks belong to the Indians and were purchased with lease money.

UTAH An Indian family in the typical horse-drawn wagon drives past a location in the southern portion of the Paradox Basin of Utah, a few miles north of the San Juan River. Note the rugged terrain which contributes to the very high road and location costs.

It is expected that 75 percent of this line's capacity will be produced in Utah; the remainder in northern New Mexico's San Juan Basin.

The line represents a $50 million investment against the reserves already proved and in sight in the Paradox and San Juan basins. Participating in the Four Corners Pipeline Company are Continental Pipeline Company, Gulf Oil Corporation, Richfield Oil Corporation, Shell Oil Company, Standard Oil Company of California, and The Superior Oil Company.

This pipe line is one of three proposed to handle crude from the two basins. It is the first to materialize in terms of contracts let and materials on site. Credit is due this line for the substantial development program already underway and planned for the near-term future.

Drilling Plans. Shell Oil Company, a pioneer in Paradox Basin exploration, will drill 100 wells in the Four Corners area this year. Of these, 40 will be in San Juan County, Utah; the remainder in the general Bisti area in northwestern New Mexico.

Carter Oil Company has five rigs busy in the area. It plans to keep them working through the rest of the year; probably much longer. Three are on development work. Two are drilling exploratory holes.

The Texas Company, discoverer of Aneth field, has a substantial program mapped out in the area. It has been steadily busy since opening Aneth and East Aneth fields.

Plans of these companies make up but a fraction of the total work projected during 1957.

Development drilling has as its immediate objective filling the needs of one or more pipe lines when they are finished. First of these will be the Four Corners Pipe Line.

Rigs Running Double Last Year's Count. Currently, 45 active rotary rigs are counted in Utah. The great majority of these are in the Paradox Basin. This is double the rig census in the state a year ago. More than 100 rigs are running in the combined Paradox Basin-San Juan Basin area. The count a year ago was 64.

Twenty-one companies reported a total of 41 seismic crews at work in the Four Corners area in late June. Some of the crews feel like natives. For instance, Shell has maintained a seismic party in the area since 1951.

A count late in June showed 50 active operations in San Juan County, Utah, alone. This included 18 different operators. It did not take into consideration increased activity in Grand County, to the north, or in Emery County, to the northwest.

The 50 active drilling operations in San Juan County alone during June should be compared with the entire year's total of 145 completed Utah wells in 1956, and the 1955 total of 91 completions.

Considering the area to be developed, the fact that a market for crude is being provided, and the very substantial investments made to date, most Rocky Mountain observers are predicting at least five years of high level activity in the Paradox Basin area alone. Completions in Utah this year will at least double the total for 1956.

15,000-20,000 Square Miles. The term "Four Corners" properly refers to a small area surrounding the four state junction of Colorado, Arizona, New Mexico and Utah. At the moment, the name is used loosely by the oil industry to cover the San Juan

Basin in northwestern New Mexico and southern Colorado, and the Paradox Basin, principally in southeastern Utah, but extending in some degree into each of the other three states.

The San Juan Basin is roughly circular, comprises some 15,000 to 20,000 square miles, takes in all of San Juan County and parts of McKinley, Rio Arriba, Sandoval, Valencia, and Bernalillo counties in New Mexico. The northern portion of the basin extends into southern Colorado; takes in parts of several counties there.

The Paradox Basin lies south of the Uinta Basin, southeast of the San Rafael Swell, and east of the Kaiparowits Basin in Utah. Its eastern border is the Uncompaghre Uplift in western Colorado. It extends into the northwestern corner of New Mexico, and into the northeastern corner of Arizona. The so-called "Four Corners Uplift" lies between the two basins, forming a rather indefinite separation.

In the San Juan Basin, surface exposure is of Tertiary and Cretaceous rocks. The large gas development in the Blanco area is based on Cretaceous production. In the Paradox Basin, Jurassic, and some Cretaceous rocks are exposed. Production is from Pennsylvanian.

The two basins include some of the most isolated areas of the nation. In the Paradox Basin, particularly, an almost roadless condition exists. The terrain is extremely rugged; seemingly far more fitted to the Zane Grey novels which were set in the area, than to the modern story of oil development which now is being unfolded there.

Both basins have long histories of oil activity, although neither became a major consideration in the domestic oil and gas industry until a relatively few years ago.

First Oil in 1911. In the San Juan Basin, the first oil discovery in New Mexico was made at Seven Lakes in 1911. The well was intended for water. Gas was discovered near the town of Aztec in 1920. Oil was found at Hogback in 1921.

Ute Dome, Bloomfield, and Rattlesnake, in New Mexico, and Red Mountain in Colorado, followed from 1921 through 1924. In 1926 gas was discovered at Blanco and at Hospah. Other discoveries followed in the general area in 1927. Pennsylvanian oil was found at Rattlesnake (Paradox Basin) in 1929.

Development dragged until modern exploitation of the Blanco gas pool was begun in 1946. More than a million acres were proved productive of gas from Pictured Cliffs within the 10 years following the end of the war.

In 1950, a pipe line to southern California from the San Juan Basin was approved. Drilling based on this market was heavy until 1953. In 1954, while uncertainty existed as to the fate of the then-pending Pacific Northwest Pipeline, drilling receded. With approval and construction of this line, a new wave of gas activity struck the basin. It still is gaining momentum.

Bisti Discovery Starts Oil Play. In 1955, El Paso Natural Gas Company found oil in Gallup (Cretaceous) sand at a wildcat in the Bisti area of San Juan County, southwest of major gas development in the Blanco area. This was followed by a substantial drilling program in 1956 and 1957.

Although it has been severely hampered by lack of outlet, for the crude, drilling at Bisti has continued, and now is increasing. Development is encouraged by new refinery construction in the area and the prospect of an outlet through a branch of the Four Corners Pipe Line.

Paradox Basin. Oil was found in the Paradox Basin near Mexican Hat, Utah, in 1907. Production, from a small stratigraphic trap in Pennsylvanian, was short lived. Interest was sporadic for years, although a number of wells in various parts of the basin had found oil shows. It was not until major leasing began in this basin in 1950 and 1951 that a determined effort to solve the riddle of Pennsylvanian oil accumulation in the Paradox started to build up.

A wildcat drilled in 1951 by Shell Oil Company on the Bluff Unit, near the town of Bluff, San Juan County, Utah, had important shows. It failed of commercial production, but added to the growing interest in the Paradox Basin.

In late 1954 Shell Oil's Desert Creek discovery in se se 35-41s-23e, San Juan County, Utah, was completed for a flow of 248 barrels of oil per day through small choke. This was the beginning of a string of Paradox Basin successes which is still being extended.

Desert Creek was an important factor in leasing in southeastern Utah, southwestern Colorado, and northwestern New Mexico during 1955 and 1956. It was followed by increased drilling in the general area. Several rank wildcats had good shows, but fell short of commercial production. During 1955 Shell completed another discovery in the North Boundary Butte area. This one produced 117 barrels of oil daily through $^{7}\frac{4}{64}$-inch choke.

Big Well at Aneth. Productive capability of the Paradox member of Hermosa was proved by these discoveries. It remained for "big" production to be found by The Texas Company at Aneth in 1956. This company's discovery, Navajo 1-c, c nw ne 23-40s-24e flowed 1704 barrels of oil per day from Paradox. Total depth is 5903 feet.

Shell tried a third time at Bluff in 1956, completed Unit 3, ne nw nw 4-40s-23e, for 138 barrels of oil, 31 barrels of water per day through half-inch choke from Hermosa.

North Desert Creek, in c se se 12-41s-23e, was also completed by Shell in that year. It flowed 1440 barrels of oil at completion through $^{48}\frac{}{64}$-inch choke. Shell's Recapture Creek discovery, west of Aneth and northwest of North Desert Creek, was another discovery in 1956. It had a much smaller potential. It flowed 34 barrels of oil in two hours before being shut in. Late in June, 1957, an attempted confirmation failed to find production.

The Texas Company also completed Navajo 1-j, c ne ne 20-40s-26e, near the Colorado line in 1956. It flowed 1420 barrels of oil per day through one-inch choke.

Other discoveries during the year included a small producer northwest of the old Boundary Butte field, a Hermosa discovery on the northwestern flank of the growing Aneth area,

and another south of the main portion of Aneth as it then existed.

By the end of 1956, Aneth, East Aneth (or South Hovenweep), and Recapture Creek stretched over an east-west distance of more than 20 miles, and a major field was in sight.

Gas in Arizona. Exploration also spread to Arizona during 1956. Franco Western Oil completed Navajo 1, sw nw 22-41n-28e, in the North Toh-A-Tin area of Apache County for a flow of 7,450,000 cubic feet of gas per day through half-inch choke. This well, producing from Paradox, was bottomed at 5900 feet.

In the same county, El Paso Natural Gas Company and Stanolind Oil & Gas (Now Pan American Petroleum) completed Bita Peak 1, sw sw nw 19-41n-31e, for a flow of nearly 21 million cubic feet of gas per day from Paradox. Excepting a 1955 discovery at East Boundary Butte, these are Arizona's only discoveries.

Southeastern Utah has had a series of important discoveries, relating to the trend through Aneth, through the first half of 1957. In January Superior Oil completed a discovery southeast of Aneth in 31-40s-25e. The well is reported as one of the better discoveries in the area to date.

Also in January, Shell proved a second zone productive at North Desert Creek. Work done there by mid-year led a Shell official to speculate that North Desert Creek might prove to be of a magnitude similar to that forecast for Aneth.

Davis Oil, Denver independent, on a farmout from Continental Oil, completed Navajo 1-A, c ne ne 27-41s-24e, for a flow of 1680 barrels of oil per day from 5510-5590 feet. Continental, completing a discovery at Navajo 1-H, c sw se 21-40s-25e, tested 304 barrels of oil daily from a 22-foot zone in the Hermosa.

In May, Carter Oil completed Navajo 114 No. 1, sw nw nw 8-41s-25e for 2330 barrels of oil daily through ¾-inch choke. This well produced from a 50-foot section of Paradox.

Latest of 1957 discoveries is that at Shell Oil's Tohonadla 1, w½ sw sw 35-41s-21e, which flowed 1450 barrels per day at completion.

All of these discoveries have been offset successfully, or were being offset by late June.

Carter Oil conducted a wildcat program in the extreme southeastern portion of San Juan County; had shows but no success. Drilling was done during the year east and north of Aneth near the Colorado line, north of Bluff, and west of established production.

Shell's Tohonadla, the westernmost success to date in the basin, furnished new incentive for exploration west of established trends.

By the end of the first half of 1957, continued development through Aneth, further drilling in each of the other discovery areas listed, exploration far to the north and west in Utah, and intensified work across the line in Colorado was the emerging pattern of Paradox Basin operations.

In Colorado, a substantial increase in exploration has been noted during the past year. This effort on the eastern flank of Paradox has so far been unsuccessful except for a 15 million cubic foot per day discovery by General Petroleum in the area north of Barker Creek in LaPlata County.

Aneth Area Wells. At mid-year, 1957, in the general Aneth area of the Paradox Basin, there were 3 producing wells completed and 13 locations active. East Aneth had three producers. In other new fields southeast of Aneth, there were four producers and three active locations. There were five producers in fields (including Bluff) west of Aneth. In North Desert Creek, there were seven producers and five active locations.

High Potentials in Paradox. Completions through the Paradox Basin have produced potentials ranging from a little more than 100 barrels daily to nearly 3000 barrels per day. Production is from upper Hermosa or from the Paradox member of that formation. Various names have been assigned these sections, notably the Bluff zone and Desert Creek zone. Pennsylvanian nomenclature has not yet solidified among the operators in the Paradox.

Production is from zones ranging from 15 or 20 feet to more than 100 feet in thickness. Oil averages about 40 gravity.

Observers agree that there is now, or will be shortly, some 50,000 barrels per day of sustained productive capacity in southeastern Utah.

El Paso refineries in New Mexico, shipment by truck and rail to Salt Lake City, and, for a short time, a limited rail movement to California, so far have provided the only outlets for Paradox Basin oil. There is no production history capable of providing sound engineering background for reserve estimates.

Wide Spacing at Bisti. Similarly, the Bisti oil area in the San Juan Basin has been spread over a wide area, but drilled on relatively wide spacing. The rather tight formation has given rise to much speculation as to eventual recovery. Meanwhile, drilling has continued and 8 or 10 miles of southeastward extension has been made to the original Bisti pool by Anderson-Prichard Oil, Shell, and others.

A productive trend between Bisti and the Blanco gas pool also has recently been indicated.

Pipe Lines. Plans for a pipe line by Texas-New Mexico Pipeline from the northwestern corner of New Mexico to existing east-bound facilities at Jal, N. M., are still being implemented. Within a couple of years the Four Corners area may have multiple pipe line outlets to market.

The Four Corners line to California is at the moment considered most significant, protected as it is by the shortage of crude on the West Coast.

Much of the prospective productive area of the Four Corners is on Indian lands. Most important of these is the Navajo reservation, covering 15 million acres in Utah, Arizona and New Mexico. Most of the Paradox Basin production is on Navajo lands. The tribe has also benefited a great deal from New Mexico developments along the Bisti trend, since there are extensive Navajo holdings in that area.

About 2 million acres of the Navajo reservation has been leased.

Before 1956, the highest price paid for Utah lands was $129.05 per acre. In New Mexico, bids went to $726.25 per acre for one tract shortly after the Bisti discovery.

Ute lands in southwestern Colorado sold for a bonus of $601 per acre in October, 1956, after Aneth was under development. Nevertheless, the price was high for lands more than 20 miles from major oil development. Later drilling on this high tract was unsuccessful.

In November of last year a little more than 30,000 acres in south-

eastern Utah brought more than $25 million in bonus. High bid was $3102 per acre for one tract south of Aneth.

The entire series of three sales, in November, brought more than $35 million in bonus. That was more than three fourths of all proceeds from all uses of all U. S. Indian lands in the previous year.

Exploration Costs High. Investment in the Paradox and San Juan basins is large. Drilling is expensive. A wildcat well to the 6000-foot depth necessary in the Paradox will cost nearly $100,000 if it's dry; twice that for a successful producer.

Roads, housing, supplies are problems.

Nevertheless, the outlook is such that one supply company has laid plans for a program in the area which will accommodate 200 rigs by 1958, and is listening with interest to optimistic predictions of even higher rig activity.

More Navajo land in New Mexico was leased early this year at good bonus rates. More will be offered in late 1957.

Farmington, N. M., Durango, Colo., and Moab and Monticello in Utah, have become oil towns overnight. Supply and service companies have swarmed into all of them.

Farmington has expanded northward along the highway as well as in other directions. Durango is full to the brim insofar as housing and office space are concerned.

New Companies Moving In. A few of the companies that have opened offices in the area include: Shell Oil, with a production division in Farmington; Carter Oil with offices moved from Vernal, Utah; Phillips Petroleum, Ohio Oil, Pure Oil, Tidewater Oil, Superior, The Texas Company and Gulf Oil.

Control of major operations is largely in Denver or in Salt Lake City.

Pan American Petroleum, Southern Union Gas, El Paso Natural Gas, Aztec Oil & Gas, Standard Oil of California, Superior Oil, Gulf, Texota Oil, The California Company, Atlantic Refining, Sunray Mid-Continent Oil, Continental Oil, Carter Oil, Ohio Oil, Pure Oil, Utah Southern Oil, Tennessee Gas Transmission, Humble Oil & Refining, General Petroleum and Three States Natural Gas are among companies with substantial Paradox Basin holdings.

Many of these plus Standard Oil of Texas, British-American Oil Producing, and Anderson-Pritchard Oil must be included in San Juan Basin oil development.

Shell Oil reports $7 million already spent on exploration in the Four Corners in the post war area. To this may be added land costs; investments in forthcoming pipe lines. The sum may be multiplied many times over for investments of other companies.

Investment so arrived at is the key to what may be expected in the Four Corners area in terms of exploration and production activity in the next 5 to 10 years.

The Four Corners already is a major oil and gas province. Even offshore operations, expensive as they are, have not drained off budgets earmarked for Four Corners work, say operators there.

There is controversy as to the area's ultimate reserve picture. But most of the major companies have resolved the question to the extent that they are in the Paradox-San Juan basins with both feet and a fistful of money.

—**The End**

New Crude Lines in Offing

• Four Corners Pipe Line Company building 750-mile Aneth-to-Los Angeles line.

• Texas-New Mexico surveying for a 515-mile line from Aneth to Jal, New Mexico.

• Northwest Pipe Line considering 500-mile line from San Juan Basin to Salt Lake City.

STIMULATING DEVELOPMENT in the Four Corners area are the plans to provide several crude oil pipe line outlets. Heretofore, there have been outlets for gas but not oil.

Four Corners Pipe Line Company is building a $50 million, 750 mile system from Aneth to Los Angeles. The main line, of 16 inch pipe, will have an initial capacity of 60,000 barrels daily. Ultimately, capacity could be increased to 160,000 barrels daily by adding pump stations.

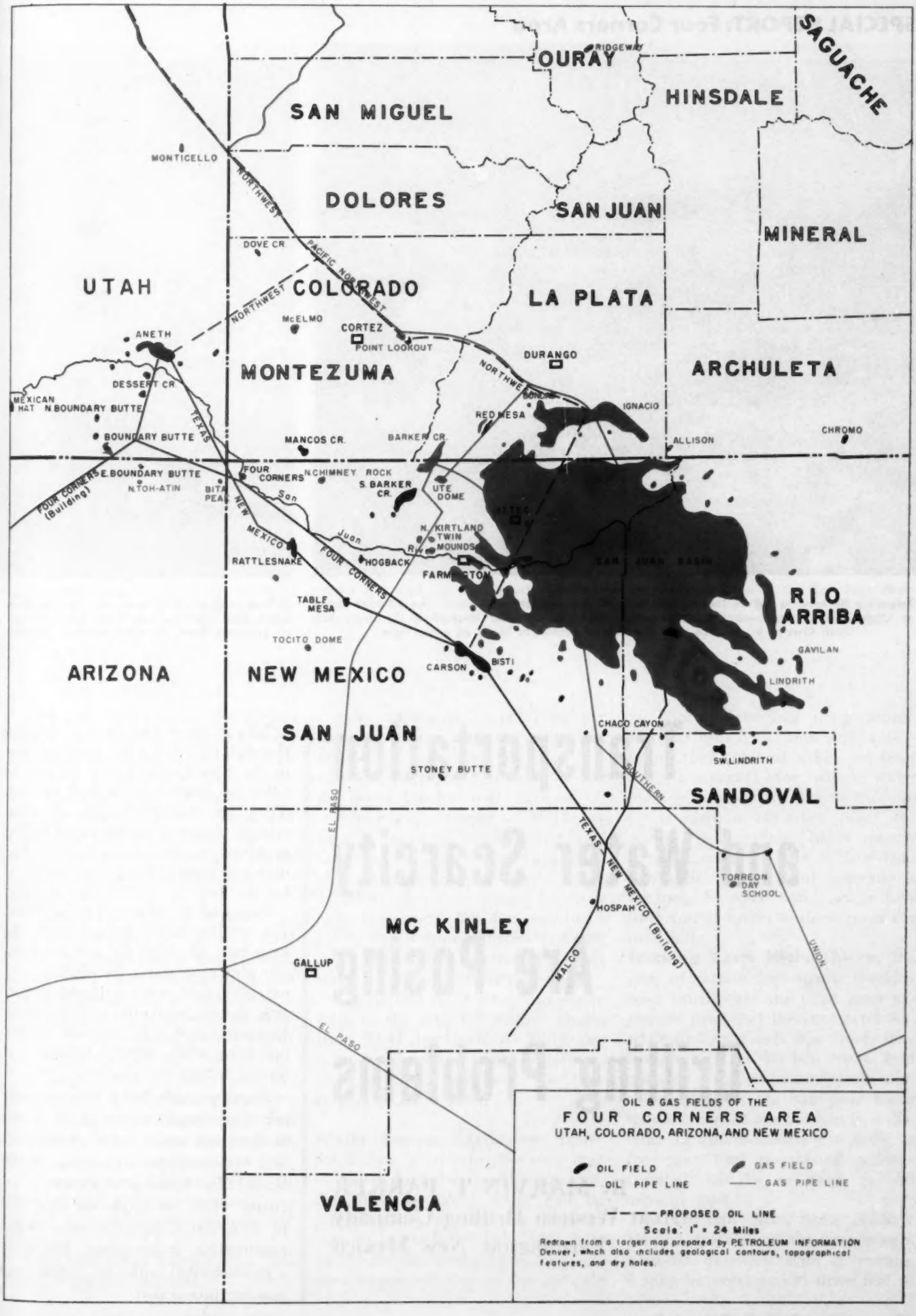
Texas-New Mexico Pipe Line Company is surveying for a 515-mile, 16-inch line from Aneth to Jal, N. M. It will have an initial capacity of 50,000 barrels daily. The company's existing system leads from Jal to the Gulf Coast. Owners include The Texas Company, Sinclair Oil Corporation, Tidewater Oil Company, and Empire Gas & Fuel Company.

Northwest Pipe Line Corporation has proposed to build a 500-mile crude and products line from the San Juan Basin to Salt Lake City. It would be of 10-, 8-, and 6-inch pipe and have initial capacity of 25,000 barrels daily. The line was first proposed in August 1956, but no contracts have been let. The company is a subsidiary of Pacific Northwest Pipe Line Company.

Four Corners Line. Contractors began construction work on Four Corners Pipe Line Company's system about July 1 in the Aneth area.

The main line will include 635 miles of 16-inch pipe from Aneth field to Los Angeles. In addition there will be 86 miles of 12-inch from New Mexico's Bisti field to Red Mesa station about 35 miles southeast of Bluff, Utah, and about 3 miles of 6-, 8-, and 10-inch feeder lines from other fields in New Mexico and Utah.

Cost of the line will be about $50 million. Stock in Four Corners Pipe Line Company is held by Continental Pipe Line Company, 10 percent; Gulf Oil Corporation, 20 percent; Richfield Oil Corporation, 10 percent; Shell Oil Company, 25 percent; Standard Oil Company of California, 25 percent, and Superior Oil Company, 10 percent. Shell Pipe Line Company will design, construct and operate the line. —**The End**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ARIZONA
NEW MEXICO
CARSON
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CHACO CAYON
SAN JUAN
SW. LINDRITH
STONEY BUTTE
SANDOVAL
TORREON DAY SCHOOL
HOSPAH
MC KINLEY
GALLUP
MALCO
VALENCIA
OIL & GAS FIELDS OF THE
FOUR CORNERS AREA
UTAH, COLORADO, ARIZONA, AND NEW MEXICO
OIL FIELD
GAS FIELD
OIL PIPE LINE
GAS PIPE LINE
PROPOSED OIL LINE
Scale: 1" = 24 Miles
Redrawn from a larger map prepared by PETROLEUM INFORMATION Denver, which also includes geological contours, topographical features, and dry holes.

Preparing to move a rig in the rugged area of the southern portion of the Paradox Basin in Utah. Note typical winding, rough road, extensive clearing involved in location. San Juan River is in distance, just this side of prominent bluffs at upper right.

Drilling well in Bisti field of SW San Juan Basin, New Mexico. Long water hauls are one of problems here. In some sectors, unstable

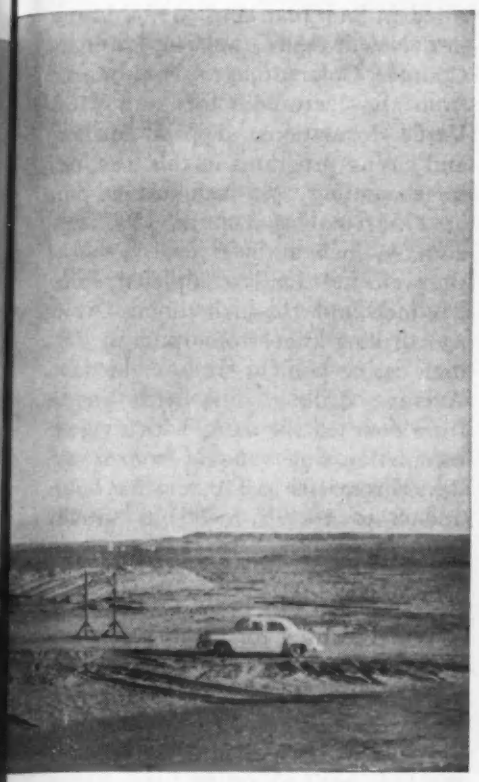
Transportation and Water Scarcity Are Posing Drilling Problems

By MARVIN T. PARKER
Great Western Drilling Company
Farmington, New Mexico

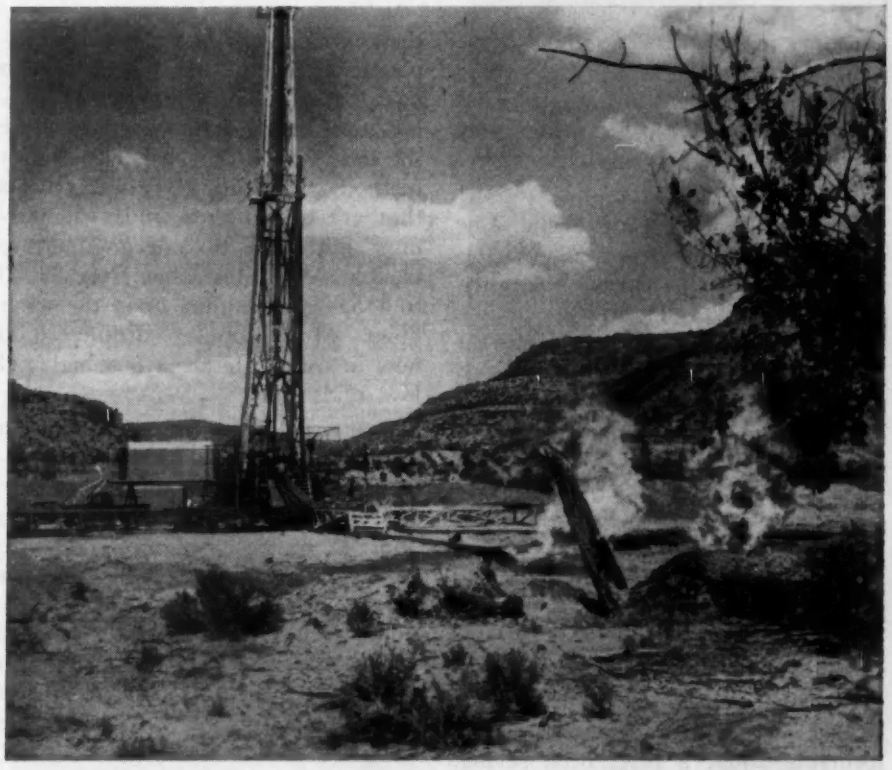
MAJOR PROBLEMS which concern the drilling contractor and operator in the Four Corners area do not involve so much the actual drilling. They are connected with all other related phases of operations. Drilling problems are not complicated. The use of a good drilling mud seems to be the key to trouble-free drilling.

Principal problems appear to be: (1) getting crews to and from the locations; (2) high rig moving costs; (3) obtaining water for drilling; (4) excessive time often required in getting service companies out to remote locations; and (5) over-all higher operating costs, due to terrain and during winter the weather.

Approximately 100 rotary rigs now are operating in this area. It is one of the most active areas of exploration and development drilling in the U. S. This figure is expected to increase when the crude oil pipe line to Southern California, now under construction, is completed, providing a much-needed outlet for rapidly expanding production.



sand surface must be dozed out and filled with shale to provide suitable base for rig, as was the case for rig shown here.



Here's a typical rig drilling with gas in the gas-producing area of the San Juan Basin. Note the flares in the right foreground. Topography shown in this photograph is typical of this portion of the Four Corners area, a challenge to continued activity.

This remote region of the Southwest is an extremely rugged terrain. It ranges in elevation from 4500 to 8000 feet. It has numerous canyons, dry, sandy washes, and surface formations that are mostly sand and shale. The problem of crew transportation and driving time is a major one. No all-around solution has been adopted.

Roads in the San Juan Basin of New Mexico generally are very good in dry weather. But in the Paradox Basin, they are rougher, and the driving time usually is much longer. Both areas are criss-crossed with dry washes. In some areas, a few streams have to be forded. These washes are very troublesome in rainy weather. They slow down operations considerably. On a few occasions, some rigs have been shut down for a short while.

Transportation plans currently being used by drilling contractors operating in remote areas include the following:

- An additional $2 per day per man on remote locations.
- An additional $5 per crew per day, and $50 per man per well when the well is completed.
- An additional $10 per day for the driver for 100 miles or over.
- Base pay increase of $0.15 per hour for a one- to two-hour drive one way, and $0.25 per hour for a drive of over two hours one way.

A few camps on remote locations have been used. But the cost for a good camp is approximately $100 per day. The drilling contractor cannot stand this at present footage rates.

The present drilling contractor pay scale in the area for drillers ranges from $2.41 per hour to $2.76 per hour; for derrickmen and motormen, $1.91 to $2.12 per hour; and, for helpers, $1.81 to $2.01.

Water Scarce, Expensive. Water for drilling is an expensive item that usually is furnished by the operator. On some locations, water can be pumped from streams. But in most cases, it has to be hauled. During the winter months, pumping water is almost impossible, due to the prevailing below-freezing temperatures. Hauling usually is done with a 105-barrel tank truck at a $14 per hour rate. Distances over which water must be hauled may range from 5 up to as high as 30 miles. Since the water is so expensive, there usually is not enough for safe drilling with water. So a good mud generally is cheaper. In some cases, water bills have run as much as three times the mud bill.

Trucking Costs High. Due to the type of terrain and roads, trucking costs usually are the third most expensive item that the contractor has while drilling a well. Rig moves may run as high as $15,000 for a field move. If a rig has to move from a location south of the San Juan River to a location on the north side, a distance of approximately five miles as the crow flies, the actual mileage traveled may be as much as 150 miles by road.

In the San Juan Basin of New Mexico, because of the very rough, mesa-and-dry-wash type of terrain, it may be necessary to drive five to

10 miles just to travel from one location to the offset location. In some instances, actual mileage involved from one location to an offset may amount to several times that figure.

The practice of the operators of letting multiple contracts in the same area, where possible, has cut the contractor's moving costs considerably. Until recently, all the rig moving trucks had to be roaded from Farmington to the Aneth field. The road time there and back usually amounted to around 12 to 15 hours. More recently some trucking contractors have located near the field. This problem now is not as severe as in the past.

Moving of equipment during bad weather, or when the washes are up may triple the cost of the move. At times, during the summer months, when the San Juan River is low, trucks can ford it at some places, bringing about a substantial saving.

In the past, a shortage of trucks has caused some delays in moving rigs. But at present there are sufficient trucks to take care of the immediate need. The types of trucks required in most cases are the 15-ton and over-15-ton tandems. The smaller single-axle trucks are sometimes used on long moves where no hills are to be pulled when loaded.

Aneth Area Water Flow Problem. In the Aneth field area in San Juan County, Utah, some operators set conductor pipe, usually 13⅜-inch, at about 60 feet, then set 1000 to 1500 feet of 9⅝-inch casing, then 5½-inch at total depth of about 5600 to 5800 feet. Purpose of the conductor pipe is to be able to control water flows if encountered. There is no pattern of occurrence of water flows. They may be encountered in one location and not on the offset. Flows have been encountered at various depths, from near conductor pipe depth down to 3000 feet, and with volumes of up to a 6-inch stream.

Other operators set 8⅝-inch surface pipe at around 1000 feet, and let the water flow until the pipe is cemented to shut it off. This does not present as much of a hole problem as it does a surface problem. A large water flow could wash out from under the substructure. Some of these water flows take 14- to 15-pound mud to hold them when mudded up. But the practice of drilling and letting it flow seems to be the most economical, if not the safest method. There are small water flows that are encountered under the surface. But these do not give serious trouble. Mud bills range from $3000 to $15,000, depending upon the water flows. Most popular drilling fluid now in use in the area is a high pH low solids mud.

Average drilling time in the Aneth area ranges from 24 to 28 days. Rotating hours amount to from 300 to 350, with bit consumption of from 30 to 35. Average drilling weight runs from 30,000 to 55,000 pounds. In one particular well drilled on the eastern side of Aneth field, hole was drilled in 20 days from spud to coring point at 5520 feet. In this well, 205 feet of 13⅜-inch surface pipe was set and 12¼-inch hole was drilled to 1480 feet. At that point hole was reduced to 8¾-inch and drilled to total depth with no trouble. Drilling fluid used was a high pH, low solids oil emulsion mud. The hole was in good condition for coring and logging.

About the Author

MARVIN T. PARKER is assistant district drilling superintendent in the Farmington, N. M., district for Great Western Drilling Company. He started as crewman and worked up to driller, drilling engineer and to his present position. Parker graduated in 1942 from Kermit, Texas, High School, then served for three years as pilot in the Air Force. He attended Texas Technological College, Lubbock, Texas, and graduated in 1952 with a degree of B.S. in petroleum engineering.

San Juan Gas Area Problem. In the San Juan gas producing area located in San Juan and Arriba Counties, New Mexico, and in La Plata County, Colorado, gas is produced from the Pictured Cliffs and Mesa Verde formations. Typical drilling and casing programs in this area call for cementing 10¾-inch surface pipe at 175 feet, 7⅝-inch at 3500 feet, and 5½-inch at 5900 feet. Some of the wells are dually completed, using 2⅜-inch and 1¼-inch tubing. Average drilling time from spud to 7⅝-inch casing point is six to eight days. Average drilling time with gas is from four to six days, with average completion time ranging from 6 to 8 days. From 100 to 110 rotating hours and 8 to 10 9⅞-inch bits usually are required down to 3500 feet; and from 50 to 60 rotating hours and 4 to 6 6¾-inch bits down to 5900 feet.

Water is used for drilling to about 2500 feet, followed by a fresh water gel chemical mud down to the 7⅝-inch casing point. A 35- to 40-second viscosity usually is sufficient to clean the hole until about 24 hours before the hole is to be logged, at which time the viscosity is raised to about 60 seconds.

There are some lost circulation problems but none very serious. There are a few crooked hole areas. But these can be taken care of by running stabilizers, reamers, and large collars on bottom. The weights carried on the 9⅞-inch bits vary from 35,000 to 60,000 pounds; penetration rates increasing with the amount of weight used. Most pumps used are 14- and 16-inch stroke, and rigs are of the 500 horsepower class and under. This applies, also, to most of the other Four Corners area. There is a noted increase in penetration rates if jet bits are used down to approximately 3000 feet.

Typical drill string consists of 4½-inch drill pipe and 6- to 8-inch drill collars. Gas drilling requires 3½-inch drill pipe and approximately 15,000 to 20,000 pounds of 5-inch drill collars to drill the 6¾-inch hole. The only problem in drilling with gas is when water comes in to prevent the well from "dusting." If water is encountered, it causes a balling action, and will stick the drill string if hole is not dried up before resuming drilling operations. The average amount of gas used is about 2½ million cubic feet per day while drilling with about

200 pounds per square inch standpipe pressure.

In the past, when the producing formation was sand and oil fractured, there was danger of fire. Most gas wells now are sand and water fractured, and the fire hazard is greatly reduced.

The O.D. wear on tool joints and drill pipe is not considered excessive while drilling with mud. But when drilling with gas, there is a rapid wear of the tool joint elevator shoulder. The annular velocity of the gas is approximately 3500 feet per minute, and when it is carrying sand, it is a very effective cutting tool. With square shoulder tool joints, the tendency is to round the shoulders off, and with 18-degree pipe, to make a square shoulder. It has been noted that a granular tungsten hard band near the shoulder will accelerate the cutting action.

Footage prices in the gas field area range from $5.00 to $5.25, depending upon whether the well is drilled on footage rate all the way with a water clause, or drilled to the 7⅝-inch casing point on footage rate, then on day work rates to total depth. The average mud bill in the area, excluding wildcats, runs from $500 to $1500.

In the Jicarilla gas and oil field in the southeastern part of the San Juan Basin, problems are about the same as in the rest of the basin. But a better drilling mud is required from the surface pipe to total depth. Most operators in this area are using a low-solids oil emulsion mud with very good results. Prior to the use of this type of mud, much trouble was encountered running logs and in sticking of drill pipe soon after drilling out from under the surface pipe.

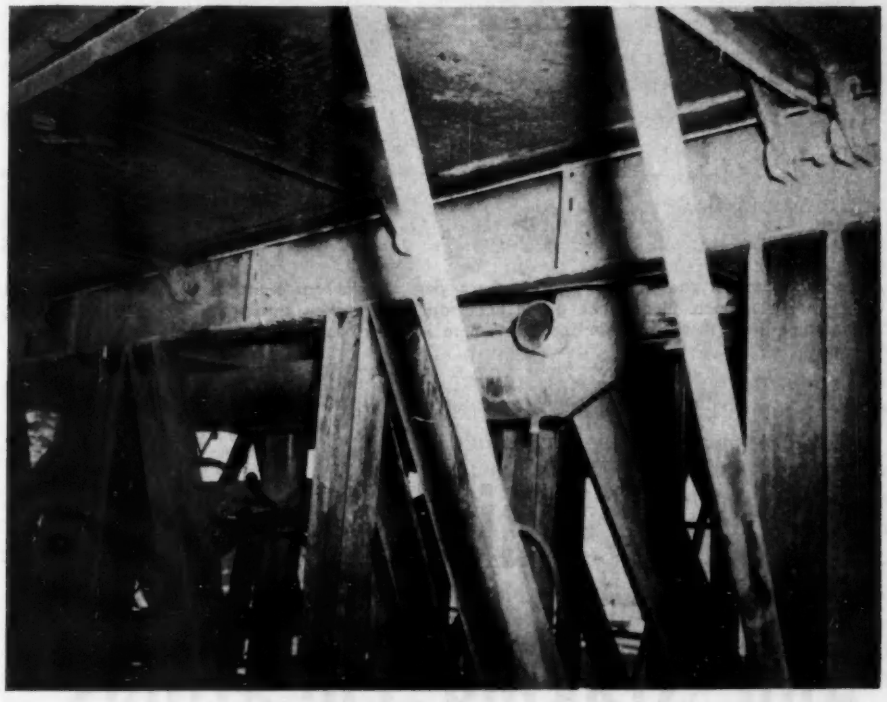
One operator in the Jicarilla area obtains drilling water by bulldozing 10-foot deep sumps in sandy bottom lands and washes. Water, largely from snow that has melted and seeped underground, seeps into the pits and is pumped out and trucked to the rig.

Bisti Oil Field Practices. Long water hauls is one of the most serious problems encountered in the Bisti oil field in the southwestern part of the San Juan Basin area. There are no crooked hole or blowout problems in the area. In the typical well, 8⅝-inch is cemented at 250 feet and 5½-inch at 5000 feet. Drilling to total depth usually requires from nine to eleven drilling days and about 140 to 150 rotating hours.

Some of the wells are drilled with water to about 3500 feet, then mudded up to total depth. The only mud problem is with solids building up the weight. Some operators are using desander units to control the weight. It is believed that an excessive mud weight has a tendency to mud off the pay zone. Oil wells in the field usually are sand and oil fractured.

Footage prices in the Bisti area range from $3.65 to $4.50 per foot, depending upon who furnishes the water. Mud bills range from $500 to $1500.

Rig Floor Heating Problem. During winter months, the problem of heating the rig floor while drilling with gas has been a complex one. Some rigs are equipped with a forced air type heating system that has a gas heater and blower located some distance from the rig floor. Another —but expensive—type is the use of a boiler. Still another type, one that has no flame hazard, consists of reversing the drilling engine fans and mounting a hood on the front of the radiators (see photographs), so engine heat can be delivered by large diameter under-floor ducts to any part of the rig floor and adjacent dog house. The light sheet metal hood easily is bolted on or removed. Volume of air delivered can be regulated by opening or closing small doors on the front of the hood. —**The End**



Heating rig floor areas without flame hazard while drilling with gas can be done inexpensively by mounting hood on engine radiator and reversing fans. Hot air forced into hood is delivered through under-floor ducts to various parts of floor and doghouse. Vents regulate volume. Shopmade light sheet hood is easily bolted on or removed from radiator front. (Photo at right.) Below is an underfloor view of engine heat circulating system. Engine heat, coming down into duct at left, re-emerges beside driller on derrick floor. Smaller outlet, visible near elbow, delivers heat to doghouse when connected.

An access road in the Largo area, southern part of the gas-producing region of San Juan County, New Mexico. Note steep grade necessary to get from canyon level to top of rimrock. In one such area, to travel from one location to its offset location required 51 miles of driving.

Building Roads And Staking Locations Are Important Cost Factors

By J. P. LEESE

San Juan Engineering Company
Farmington, New Mexico

THE SAN JUAN BASIN can be divided into several major areas of interest. Each area contains its own individual problems. In early 1951 well location work was limited almost strictly to gas wells. The main area of operation was from Blanco, 25 miles east of Farmington, eastward to the Carson National Forest. That was about 30 miles of the roughest, muddiest roads a jeep ever crawled over.

Nearly every location to be staked in those days was from one to 20 miles off of a traveled road. It was necessary to jeep or walk into and out of each well location.

In 1952 there were orders to stake wells out in the Carson National Forest area. During the winter it turns into a winter wonderland, which might be nice to look at and play in but is hard to survey in. Well locating crews had to leave town at 5 a.m. and fight mud and snow all day long and come in at 10 or 11 that night with, if lucky, one location staked, only to find that it was necessary to start back again the next morning on another job.

The crews kept looking forward to warmer weather and the day when the snow would be gone. Warmer weather came and the bottom dropped out of the roads. Even a jeep couldn't get through until all of the snow was gone and the roads were dry again. There is still an occasional job out there, but most of the drilling activity has moved to other areas. An effort was made to get to a location in the forest recently, and it was found that there are now lots of roads. But most of them were washed out at the creek and arroyo crossings.

In 1952 and 1953 the gas well drilling expanded in all directions. Kutz Canyon south of Bloomfield had long been a good producing area, and during this period most of the gaps were filled in.

Pump Canyon and westward past Cedar Hill began to see considerable activity. The pipe lines of El Paso Natural Gas Company and Southern Union Gas Company began expanding all over the countryside.

In that district were hilly or mountainous terrain, no roads, and very often no survey control to work from. Most of the areas where well locations were staked seemed invariably to fall in townships that had been surveyed before 1900. In most cases the interior section corners did not exist. Many

times in order to stake a well, it was necessary to run lines across the entire township, both east and west and north and south. Elevation lines had to be extended into these areas.

The first company into an area usually stood the cost of laying the ground work for subsequent work. The companies that followed reaped the advantage in that their surveys now came from nearby established lines.

Largo Canyon is another of those areas which developed in 1952 and 1953. In the Largo Canyon Area was the famed Doswell pool, the first oil production to be found in the gas field proper. Largo Canyon is an area of deep canyons and very rough terrain. The Canyon itself is a wicked arroyo, filled with quicksand and enough seepage of water to make it dangerous to cross even in dry weather. The Largo, as it is referred to, heads down on the South end of the Jicarilla Apache Indian Reservation.

South Jicarilla began to show life in 1954. There again was the same problem of very few roads and a vast expanse of land to survey in, with very few section corners to work from. The entire area had only a few rock corners or was completely unsurveyed. When it rained, the roads quickly became impassable, except for four wheeled drive vehicles.

The south Jicarilla area is rapidly being developed, but there is still considerable wildcat activity. New gas discoveries are announced nearly every week. To get to the area it is necessary to drive almost 80 miles from Farmington down the main highway toward Albuquerque, then turn north off of the pavement, and enter the Jicarilla Apache Reservation. It extends 65 miles north and is 20 to 25 miles wide. Here are some of the Apaches, still herding their sheep, as of old, and using horses and wagons to get around in. However, the Apaches as a whole are a rather wealthy tribe.

The search for oil has spread to the south Jicarilla, as interest in the newly discovered Gallup sands increases. Nearly every wildcat announced lately has plans for testing the Gallup.

Bisti Field. Late in 1955 El Paso Natural Gas Company drilled a wildcat in what is known as the Bisti field, and accidentally drilled into a pool of oil. Thus was made the discovery of the Gallup sands as a producer in the San Juan Basin. It was not long before drilling was under way in earnest, to find the limits of this pool. There have been dry holes, but there are many more producers than dry holes. The area of interest is growing larger day by day. The Gallup sands are being searched out and tested miles from the original discovery. Although there have been no big discoveries, there are many small producers being completed in many of the outlying areas.

El Paso recently brought in another very good producer six miles north of production in the Bisti field. An order was received to stake another location for British American two miles north and west of El Paso's well. A week later a British American man wanted immediate staking of a tank battery site. They had a producer. The surveyor finally got a break in the Bisti field. Here is an area that is not very rough. There are Brass Caps on the section corners to work from, and nearly all are in place.

The biggest news as far as the San Juan Basin is concerned came with the discovery of oil by the Texas Company in the Aneth field in 1955.

Shell's geologists had long contended that some day one of the largest oil fields in the nation would be developed in the Four Corners area of Utah and Arizona. Before any other major company showed any particular interest, Shell was busy running seismograph and gravity meter surveys over the area.

About the Author

JAMES P. LEESE bought into the San Juan Engineering Company, Farmington, N. M., and has been running it since June 1, 1952. He managed Nickelite Paving Company, in which he owned a one fourth interest, from 1946 to 1952. After attending the University of New Mexico 1934-1937, Leese worked on highway surveys and construction from 1937 to 1942. He worked for the U. S. Corps of Engineers as surveyor and layout chief, 1942-1943. He enlisted as buck private in the Army Engineers in June 1943, and came out of the Army as a first lieutenant in June 1946.

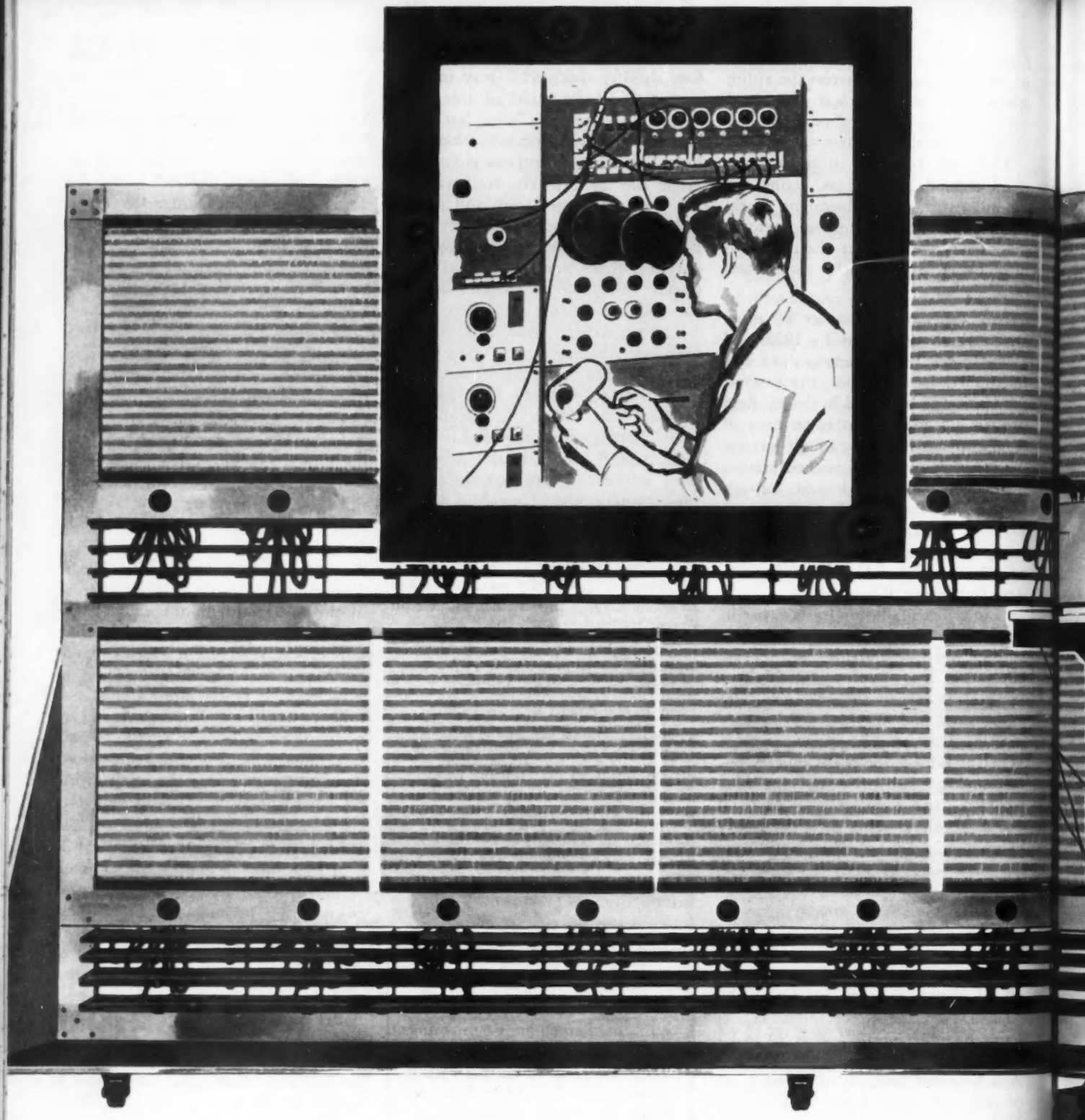
They concentrated most of their activities south of the San Juan River. The entire area at that time was unsurveyed. Before the Navajos could even think about leasing, the entire area had to be at least laid out on paper, and tracts of land had to be described in such a manner that when the land was surveyed the survey point would at least fit the leased lines as described. Shell put their vast resources to work to prepare these descriptions, and set about preparations for a public letting.

Shell's interest in the area stirred other companies into bidding on the tracts, also. At the end of this first letting there were probably two dozen lease holders in the area. Shell took the largest portion. Carter Oil Company was next. Ohio Oil took the third largest portion, with Superior Oil in fourth place.

Desert Land in Utah. The Texas Company did not show much interest in the area south of the river. They set about picking up acreage in that part of the Reservation which extends north of the river in Utah. This is a bleak, dry, desert land, almost too arid to sustain life. But even here can be found an occasional Navajo Indian hogan and a herd of sheep and goats. This land is bitterly cold in the winter when the wind starts to blow. In the summer it gets like an oven, and the soil dries up and turns to powder.

A road built in here in the summer time has to be wet down during the construction period at night to keep the water from evaporating before it can penetrate the soil and do any good. If you are riding in the area and decide to turn around, you had better be very careful to not get your rear wheels off of the compacted road bed, because if you do, you are apt to suddenly find your rear wheels buried to the axle in the soft, fluffy soil. When there is any moisture in the soil, it is possible to drive almost anywhere, if a certain amount of caution is exercised. Early well surveying work in this area was in the summertime, before any roads were built, and there was quite a problem in getting around.

This part of the reservation north of the river had been surveyed back in the 1880's. The survey was surprisingly good, but it was a terrific job to locate the rock corners. It seemed that most of the corners fell where



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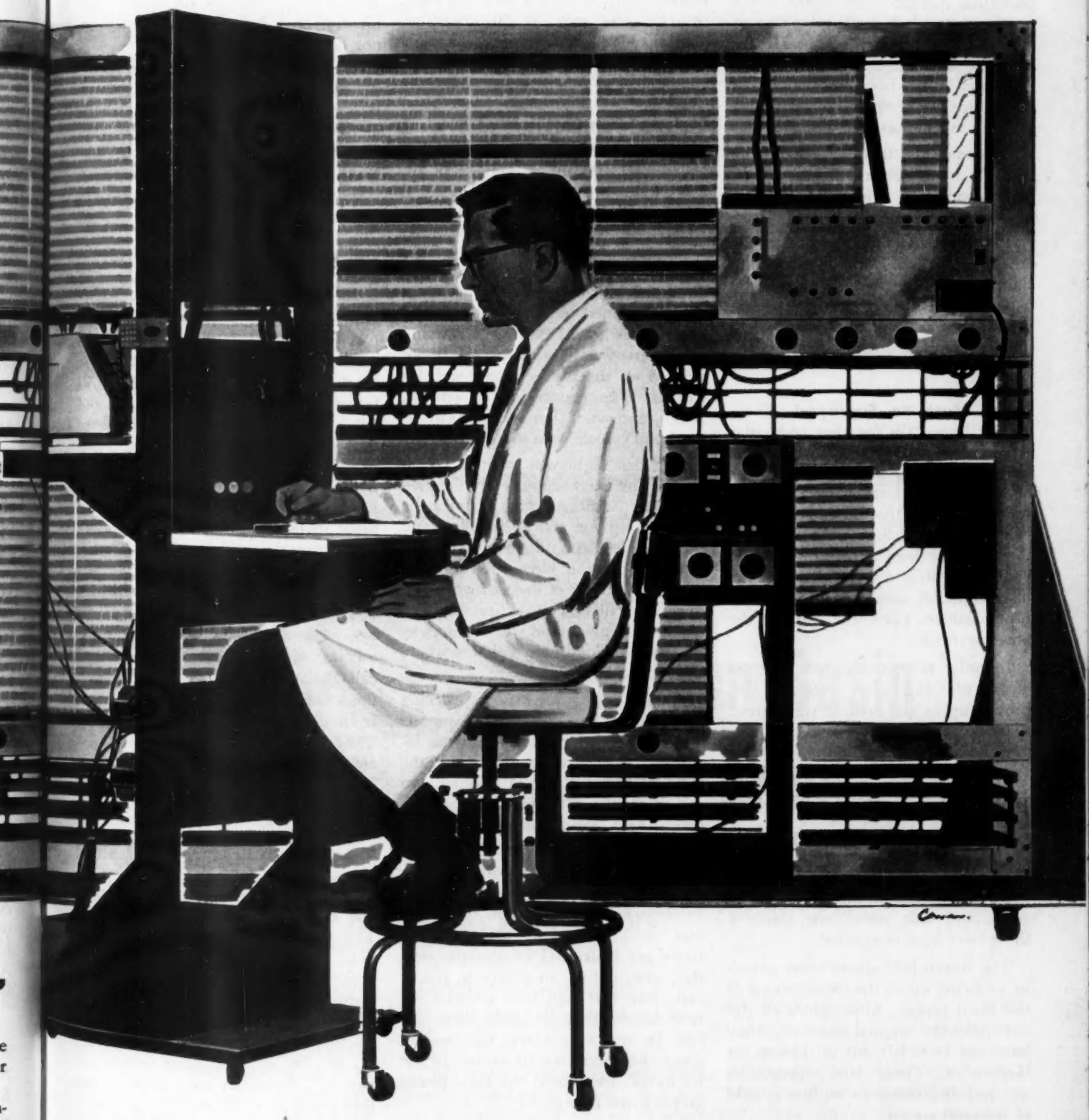

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there were literally acres of rocks lying around. In order to find the particular marked stone sought, it was necessary to start out by looking at every rock big enough to put a mark on. The stone sought might luckily be found in an hour, but finding it might involve a whole day searching an area as small as a city block.

This same soil that can be so mean when it is entirely dried out can be just as bad when it is raining or after a rain.

The Texas Company lease in the Aneth field is well over 100 miles from Farmington. The first 70 miles is on a paved road, but after that it is on roads about as rough and dusty (when dry) as any in any oil field in the world.

Lease Must Be Surveyed. Every Indian lease calls for that particular lease to be surveyed before a well may be drilled. After the first leasing of tracts in this Utah area, a meeting was held with the Bureau of Land Management in Salt Lake City. All of the major leaseholders in the area being present, it was decided that the oil companies would each pay their proportionate parts for having the area surveyed.

In order not to have too large an outlay of cash before anything was proven up in the area, it was agreed that the Land Office would only survey the exterior boundaries of each township at that time (1953). Then as the individual company got ready to drill, they could complete the survey of the particular tract they wanted to drill. Each tract was comprised of four sections. Work on these tracts has been in progress, on and off, for four years, and only about one third of them have been completed.

The Aneth field shows every promise of living up to the expectations of the Shell people. Although Shell did not make the original discovery, they have not been left out of subsequent discoveries. These later discoveries are just beginning to outline a field of tremendous size.

With the stepup in exploratory drilling due to these prolific discoveries in the Aneth and adjoining areas, surveyors are continually being called upon to go further afield to stake well locations, make surface inspections, tract surveys and do a dozen other related items of survey work. A crew recently was sent as far away as Vernal, Utah, to survey a location and elevation for one of the major companies.

Staking Utah Locations. Typical of some of the rougher locations was the assignment recently to stake two locations and furnish elevations at two separate sites about 50 miles south of Green River, Utah. The party left Durango, Colo., one afternoon with two vehicles, (four-wheel drive equipped with winches) and five men. It was planned to run the equivalent of two crews, two men to be running elevations while the other three worked on the survey of the well locations. The country is so remote, rough, and wild, that it is not safe to send one vehicle on a job down there.

The first night was spent at Green River. The party set out early the next morning, went through Hanksville and beyond for about 20 miles, and then headed into the breaks on the west side of the Green River itself. This is a country of deep canyons and towering cliffs. You either have to head the canyons or work your way on foot down into one if that is where the survey takes you.

Three days were spent working from daylight to dark finding corners and running survey lines into the location. The party got back to the town of Green River at midnight on the third day, after fighting canyons, brush, heat, sand dunes, rattlesnakes and lack of water.

The men scrambled some eggs in the motel room, and everybody went to sleep happy. One more tough job was finished, it was thought. The party got back to Durango the next day, just in time to receive a phone call from the man who ordered the well surveyed in the first place. He said he was very sorry, but he had given the wrong section on one of the locations; and would the crew please go back and change it?

Pipe Line Job. The writer's company was given the job by the Four Corners Pipe Line Company to survey part of their line to California. It had all of the eastern end of the line plus the feeder or gathering lines in both the Aneth and the Bisti fields. The men were put out in trailers at Kayenta and Red Mesa, Ariz. They would leave for the job at 7 a.m. and work until 6 p.m., drive in, fix supper and hit the hay. Nobody complained of not being able to sleep.

The pipe line job has been completed, and the company is just as busy now as when half of the personnel were working on the pipe line. People say, "you haven't seen anything yet. Wait until the pipe lines are completed. Then watch this Basin get up and go."

The Navajos. Many of the Navajo Indians still have no conception of what has happened to their home land. The great majority of the Navajo people will not see any of the cash received for the lease of their lands, nor from the royalties that will follow. All of these monies go to the tribe as a whole, to be used to better the welfare of the entire tribe. Education funds are being established. More roads, schools, dams and so forth are being built. Some money is being invested in motels on the reservation, so that the tourist will stay and spend his money. These investments are paying immediate dividends.

There are, however, some Navajos who were fortunate enough to have established their homes on what they call "allotted lands." These allotted lands actually belong to the individual Indian, including oil and gas rights. They actually hold a government patent to the land and minerals. These Indians receive the lease money and royalties themselves.

Following are two of the stories that are purported to be true about certain Indians and their money. One major oil company was dickering with one Indian through a local attorney. The amount of money that the Indian was to receive for his lease had been agreed upon. The oil company wanted to give the Indian $5000 or $10,000 as a binder to the agreement. So the lawyer proceeded to explain to the Indian that they could not pay him the entire sum at once, but they could give him something now to show their good faith. The Indian replied that that was all right, and he hoped that they would not think that $50 was too much.

The other story has to do with the Navajo woman that Phillips Petro-

leum Company was paying well over $100,000 for her lease. Phillips had paid the money to the tribal officials at Window Rock, and the woman had come after it. The people at Window Rock carefully explained to her about what a tremendous amount of money was hers. They told her that she should not carry all of that money with her. They told her all about the advantages of leaving most of the money at Window Rock, where it would be safe, and where she could come for more money as she needed it. She listened attentively and seemed to agree with everything that was said. Finally, when they thought that she understood and agreed to leave the money there, they asked her how much of it would she like to take with her this time. She answered very positively, "All of it."

Well location survey costs for wells in this area run anywhere from $75 per location to $500 or $600, depending upon where the well is to be located, and how far from known survey points and elevation markers the location might be. The average cost of locating a well would be from about $100 to $125 per well. If more than one location at a time were available in the same area, costs can nearly always be held to a minimum per location, because the travel time can then be spread over more than one location. The high cost of a well location comes when only one location, and that usually a wildcat far from any known control, is ordered. That first well will be costly, but any subsequent locations in the same vicinity will come much cheaper.

The costs of building roads and location sites also vary considerably with the terrain and distance from existing roads. The average cost of building a location with one mile of road is estimated to be $3000. The average cost of road building is about $2000 per mile.

There are extremes at both ends of the scale. For a location right beside the road on flat ground, the cost would not run $500. At the other end of the scale, a location was staked for Southern Union Gas Company recently. It was estimated that the cost to build a quarter mile of road and a location at the end of the road would run in the neighborhood of $20,000. This one has not been drilled yet.

—The End

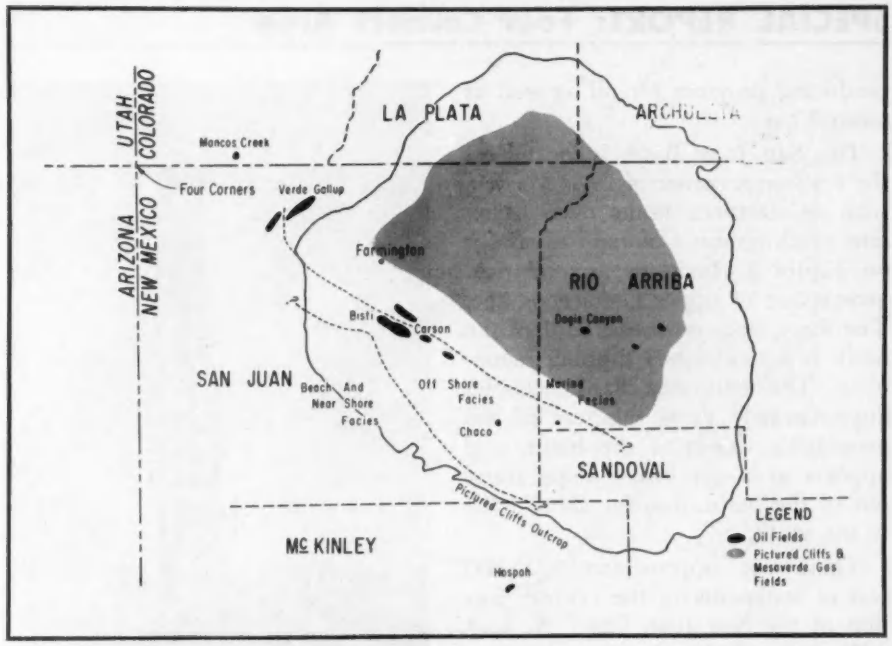


FIGURE 1—Map of San Juan Basin showing oil and gas production from members of Mancos formations.

Recent discoveries in the complex Gallup sands and the promise of a major oil reserve have spurred exploration along the . . .

San Juan Basin Rim Area

By HARRELL BUDD
Kilgore and Budd
Consulting Geologists
Farmington, New Mexico

FOR MANY YEARS the San Juan Basin has been well known for its gas reserves. Until recently, oil production within the basin has been very limited. With the thick section of upper Cretaceous sandstones in close association with black carbonaceous shales, and with the abundance of natural gas, the lack of substantial volumes of oil seemed incongruous with our preconceived notions of origin and accumulations of oil and gas.

Recent discoveries, however, seem to indicate that the San Juan Basin eventually may prove to be a major

producing province for oil as well as natural gas.

The San Juan Basin is located in the northwest corner of New Mexico, with its northern limits overlapping into southwestern Colorado as shown on Figure 1. It is an asymmetrical geosyncline of upper Cretaceous age. The short, steep northeast flank of the basin is a moderately dipping monocline. The southwest flank occupies approximately three quarters of the geographic extent of the basin, and appears as a gentle dip slope rising out of the basin onto the Zuni uplift to the south.

There are approximately 15,000 feet of sediments in the central portion of the San Juan Basin. At least 6000 feet of these are upper Cretaceous in age and include all major gas producing horizons. Recent important oil discoveries have been made in some of these upper Cretaceous formations. The purpose of this article is to discuss the occurence of this oil and outline briefly the economic factors involved.

Stratigraphy Complex. The Mancos formation in the San Juan Basin is upper Cretaceous in age. It overlies the Dakota formation, and in turn is overlain by the Mesa Verde formation. This section includes at least six members (depending upon whose terminology is applied) and occupies a total interval of almost 2000 feet.

There is disagreement and confusion in regard to the correlation and nomenclature of these various members in different parts of the basin. Without advancing any new ideas, but merely attempting to summarize the most accepted usage, the following terminology is presented:

Geophysics activity is brisk in Four Corners area. Here a crew is drilling shot holes, using air for circulating medium, in desert area in southwestern San Juan Basin, New Mexico. Air compressor is mounted on drill truck, immediately behind the cab.

The primary direction for the source of sediments that comprise the Mancos formation was south and possible southwest of the area of deposition. During deposition of these sediments several major earth movements apparently took place. These crustal adjustments are reflected in the movements of the marine seas that occupied the San Juan Basin during Mancos times. These seas, after periods of stability, apparently withdrew to a limited extent toward the northeast away from the source of sedimentation. Each withdrawal was accompanied by a migration of the different environments; i.e., beach, near shore, offshore and marine. After a period the seas would return with another environmental shift and resulting change in sedimentation. These cyclic regressions and transgressions of the Mancos seas resulted in the deposition of a series of sediments that reflect these migrations of environment.

At the beginning of Gallup times, one such minor crustal adjustment took place. There was uplift in the source area for the Gallup sediments south and southwest of the San Juan Basin. This uplift is reflected in the increased quantities of clastic material that was deposited in the southern portion of the San Juan seas during Gallup times. This sudden influx of coarse grain clastics from the unlifted area to the south, concurrent with the northeastward regression of the marine seas resulted in a migration of the various depositional environments. As a result the beach, near shore, offshore and marine environments existed northeastward of the position they previously had occupied. After this regression there apparently was a period of equilibrium, during which the deposition of clastic sediments was in balance with erosion of the seas.

During this period of temporary stabilization a series of sandbars were deposited in the offshore and marine zones approximately parallel to the shore line. These sandbars were larger and composed of coarser grain sediments near the shore. Smaller sandbars composed of finer grain sediments were deposited further away from shore. Upift in the source area and transportation of coarse grain material ceased temporarily and the seas began the return toward the south. As a result the Gallup member of the Mancos formation appears as a wedge of clastic sediments with the thickest portion toward the south.

Toward the north the Gallup thins and becomes finer in grain size. There is an abrupt change that marks the limits of the marine regression. The sediments deposited in the beach and near shore environment grade from a clean, well sorted medium grain

SOUTHWEST SAN JUAN BASIN	CENTRAL SAN JUAN BASIN	NORTHWEST SAN JUAN BASIN
Mesa Verder formation Upper Hosta sandstone	Mesa Verde formation Point Lookout sandstone	Mesa Verde formation Point Lookout sandstone
Mancos formation Satan Tongue	Mancos formation Upper Mancos shale	Mancos formation Upper Mancos shale
Mesa Verde (again!) Lower Hosta Lower Gibson Dalton sandstone Mulatto shale Dilco coal Gallup sandstone (Hospah)	Upper Gallup Lower Gallup	Niobrara "Tocito" lentil
Mancos formation (again!) Sanastee Lower Mancos shale Greenhorn limestone Graneros	Middle Mancos shale Sanastee Lower Mancos Greenhorn limestone Graneros	Middle Mancos shale Sanastee Lower Mancos Greenhorn limestone Graneros
Dakota formation	Dakota formation	Dakota formation

sandstone saturated with fresh water, northward into the offshore zone as shown on accompanying diagram (Figure 2).

The offshore zone is represented by poorly sorted lenticular sandstone and siltstone with interbedded black calcareous shales. The connate water in these sandstone lenses is salty. Apparently, after deposition, there was no communication between these isolated lenses and the fairly homogenous sandstones of the beach deposit to the south. The long dimension of these sandstone lenses was parallel to the old shore line and is approximately parallel to present regional strike.

To the north, in the marine environment of deposition as indicated on the accompanying diagram, the sediments are primarily black calcareous shales of the Niobrara type with a few very thin lenses of fine grain silty sandstone. These sandstone lenses usually occur near the base of the Niobrara section and are given the name "Tocito" athough they are discontinuous and occupy slightly varying stratigraphic position.

The present producing stratigraphic oil fields in the San Juan Basin have as the reservoir rocks these long narrow sandstone lenses of the offshore and marine facies as indicated on the accompanying block diagram. Occurrences of oil and principal characteristics of the most important oil fields along this trend are discussed in the following summary.

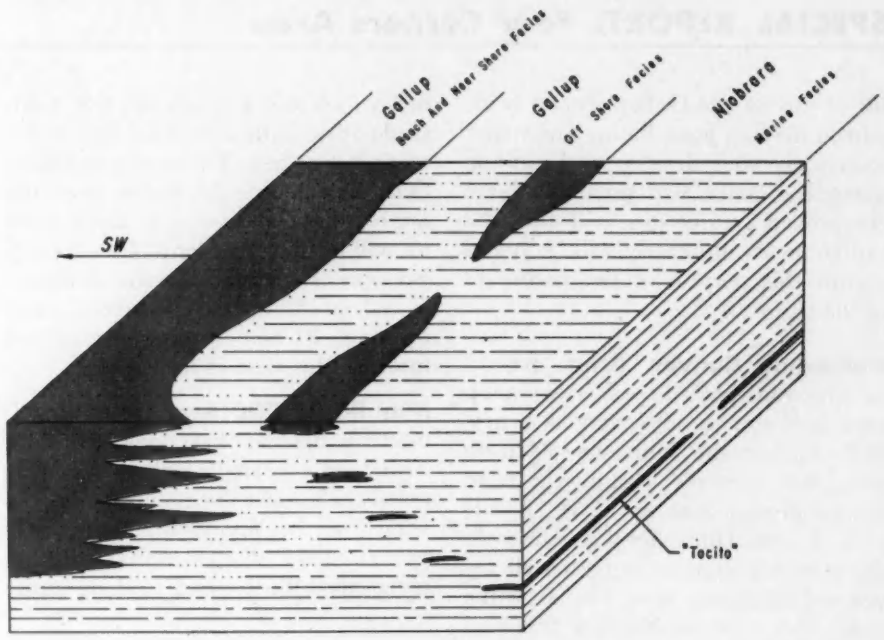


FIGURE 2—Schematic block diagram showing relationship of Gallup sandstone and its stratigraphic equivalents.

Dogie Canyon Field. The Dogie Canyon field is located in Township 26 North, Range 6 West, Rio Arriba County, N. M., near the geographic center of the San Juan Basin. The discovery well, the Doswell-Pettigrew, Scott-Federal 2, was completed for approximately 400 barrels of 42 degree gravity oil per day, in July, 1951. This field contains 11 oil wells producing from the "Tocito" lentil.

The average well has a net pay thickness of 20 feet and will produce approximately 150,000 barrels of stock tank oil before depletion. The average depth of the producing horizon is approximately 6600 feet and the subsea datum is approximately minus 100 feet on top of the "Tocito." The average cost for a completed well is $80,000. The oil is purchased by El Paso Natural Gas Products Company. It is valued at $2.50 per barrel at the wellhead. The oil is trucked to the tank battery at Lybrook where it enters the pipe line to the refinery at Prewitt, N. M.

This field is producing from a "Tocito" type lentil in the basal Niobrara shale section. It is a stratigraphy trap, with the producing zone, a lenticular body of porous, oil saturated sandstone encased in impermeable shale and siltstones. Although the limits of this particular lense have been defined, the writer feels that similar sandstone developments will be found along strike with this field.

Verde-Gallup Field. The Verde Gallup field, located in Township 31 north, range 15 west, San Juan County, New Mexico, was discovered by C. M. Carroll Drilling Company's Ute No. 1. This well was completed in September, 1955, for 190 barrels per day of 40 degree gravity oil. Currently there are 34 wells capable of producing an average of 80 barrels of oil per day. The average depth is approximately 2200 feet, and the subsea elevation ranges from plus 3350 to plus 3850 feet.

A completed well costs approximately $40,000. Crude is purchased by Oriental Refinery of Alamosa, Colo., and El Paso Natural Gas Products Company for their refinery at Bloomfield, N. M. The oil brings $2.60 per barrel at the wellhead, and is transported to the refineries by truck. The production is not prorated by the state and is entirely subject to market demand. Current daily production averages approximately 35 barrels of oil per well per day.

The reservoir in this field is difficult to define. From samples and cores, the producing interval appears to be a series of fractured, laminated sandstones and shales with a thin, fairly well developed sandstone lense at the base. In a number of cases this basal sandstone lense is not present, and some wells are producing from what appears to be an interval of fractured shale. This section is Niobrara-Tocito equivalent.

It is impossible to make any reasonable estimates of the recoverable oil per acre in this field. Short production histories are only indicative of the ultimate recovery. It appears, however that these wells have moderate decline curves and will produce substantial volumes of oil before depletion.

As an estimate, and at best it is a guess, the writer would judge an average of 2000 barrels per acre of stock tank oil will be recovered before depletion.

Because of its shallow depth and moderate cost per well, this field is one of the most commercially success-

ful of any of the Gallup-Tocito fields within the San Juan Basin. The writer anticipates that development drilling along the strike will greatly enlarge the proven area of this field and that similar fields ultimately will be found within this portion of the perimeter of the basin.

Horseshoe Canyon Area. Recent drilling southwest of the Verde Gallup area indicates the discovery of a new field. Called the Horseshoe Canyon area, the reservoir is different from the producing zone at nearby Verde pool. In the Horseshoe Canyon wells the reservoir appears to be a well developed sandstone lense, similar to the near shore type sandbars of the Bisti field. This is in marked contrast to the reservoir of the Verde pool immediately to the north, where the producing zone is the Niobrara-Tocito type section.

The limits of the field have not been defined, since it is in initial stages of discovery. The shallow, (1400 foot) depths make the economics of this field very attractive.

Bisti Field and Bisti Trend. Bisti field, located in Townships 25 and 26 North, Ranges 10, 11 and 12 West, San Juan County, New Mexico, was discovered by El Paso Natural Gas Company Kelly-State 1 in September, 1955. At this writing there are 67 completed wells producing from the Gallup sandstone member. The average depth is 5200 feet. The cost for a completed well averages $70,000. There is a wide range of reported completion gages, but 250 barrels per day appears to be a fair average. The oil is 38 to 40 degree gravity and is valued at $2.50 at the wellhead. The crude is purchased by El Paso Natural Gas Products Company, and is trucked to either their refinery at Bloomfield or the tank battery at Lybrook, N. M., where it enters the pipe line for transportation to their refinery at Prewitt.

Currently the well spacing is a voluntary 80 acres. The pipe line allowable per well has fluctuated recently because of the international situation, but is currently set at 20 barrels per day per well. The thickness of the producing zone varies considerably. However, 25 feet would be considered average. Some of the sandstone lenses are permeable enough to produce naturally. In other parts of the field, stimulation with a sand-oil frac treatment is required. The writer estimates that throughout the entire field the approximate recoverable stock tank oil will be on the order of 4000 barrels per acre. However, effective drainage of 80 acres appears doubtful, and eventual 40 acre spacing throughout most of this field is anticipated.

May Be 27,000 Acre Field. Development drilling has indicated that Bisti field eventually will be approximately 25 miles long and 1½ miles wide, with approximately 27,000 proven acres. Exploratory drilling along the "Bisti trend" (along strike with the field) has indicated that saturated sandstone lenses exist along the trend, although to date none the size and thickness of Bisti field has been reported. The well density is on the order of two to three wells per township, so the area cannot be considered tested.

In a recent publication there was a discussion of Bisti field and Bisti trend in which a comparison was made between the Gallup production of the San Juan basin and Spraberry production of West Texas. In the opinion of the writer this was not a valid comparison. To the writer's knowledge, the reservoir characteristics of the Spraberry cannot be compared with the Gallup as it appears in Bisti field, where the average permeability is in the order of 50 millidarcys, the porosity 18 percent, and the average net pay 25 feet. In the sandstone lenses of the Gallup, the reservoir characteristics vary, as is typical of most fields.

Typically, there are areas of marginal and sub-commercial production. It is entirely possible that other well developed sandstone lenses, saturated with oil, will be found in this "off shore" facies of the Gallup, probably along the strike of the Bisti field. Certainly, exploration is justified when the rewards appear to be a completed well which costs $70,000 and produces approximately $500,000 worth of oil. These figures are typical of the Bisti field. They are not typical of the Spraberry.

Field North of Bisti. As yet unnamed, another oil and gas field recently was discovered approximately five miles north of Bisti field. It is locally termed the "Sullivan area" because of El Paso Natural Gas Company's discovery well, Sullivan 1-F, located in section 32-27n-13w.

This trend is as yet relatively undeveloped. It appears that the reservoir is approximately 30 feet of very fine grain, tight sandstone and siltstone, which would be too impermeable to produce through primary permeability (on the order of .05 md.). However, the reservoir is broken by a series of vertical fractures that result in enough secondary permeability to permit commercial oil production.

Little is known of this field because of its recent discovery. It appears to be a "Tocito" type development that will parallel the Bisti field. The reser-

About the Author

HARRELL BUDD joined Lee W. Kilgore in 1956 to form the consulting firm of Kilgore and Budd. Previously he was district geologist for Southern Union Gas Company in the Four Corners area for two years. Budd received his B.S. degree in geology from Southern Methodist University in 1947. Upon graduation he was employed by the U. S. Gypsum Company. In 1948 he resigned from U. S. Gypsum and entered the graduate school at SMU. While doing his graduate work he was employed by Atlantic Refining Company. He received his M.S. degree from SMU in 1950 and was employed by Delhi Oil Corporation. He worked for Delhi for four years and was a staff geologist in their Dallas office. Budd is president of the Four Corners Geological Society; a member of the American Association of Petroleum Geologists, and the American Institute of Mining, Metallurgical and Petroleum Engineers.

voir characteristics indicate that the recoverable oil will be low, on the order of 1000 to 1500 barrels per acre.

Summary. Currently, oil exploration in the San Juan Basin is directed toward porosity and permeability developments in sandstone lenses, in what has been termed the offshore and marine facies of the Gallup member of the Mancos shale and its stratigraphic equivalents.

Development drilling has indicated that these porosity and permeability developments occur in long narrow sandstone lenses that are roughly parallel to the regional strike.

The porosities and permeabilities in these sandstone lenses are rather low. As a result the reservoirs frequently need stimulation in the form of sand-oil frac treatment before they will produce commercial quantities of oil.

The recoverable oil reserves in these sandstone lenses will be low, with an overall average of 2000 barrels per acre of stock tank oil. The low reserve is offset by the high ratio of discovery. Forty percent of the Gallup tests drilled last year in the San Juan Basin were completed as commercial wells.

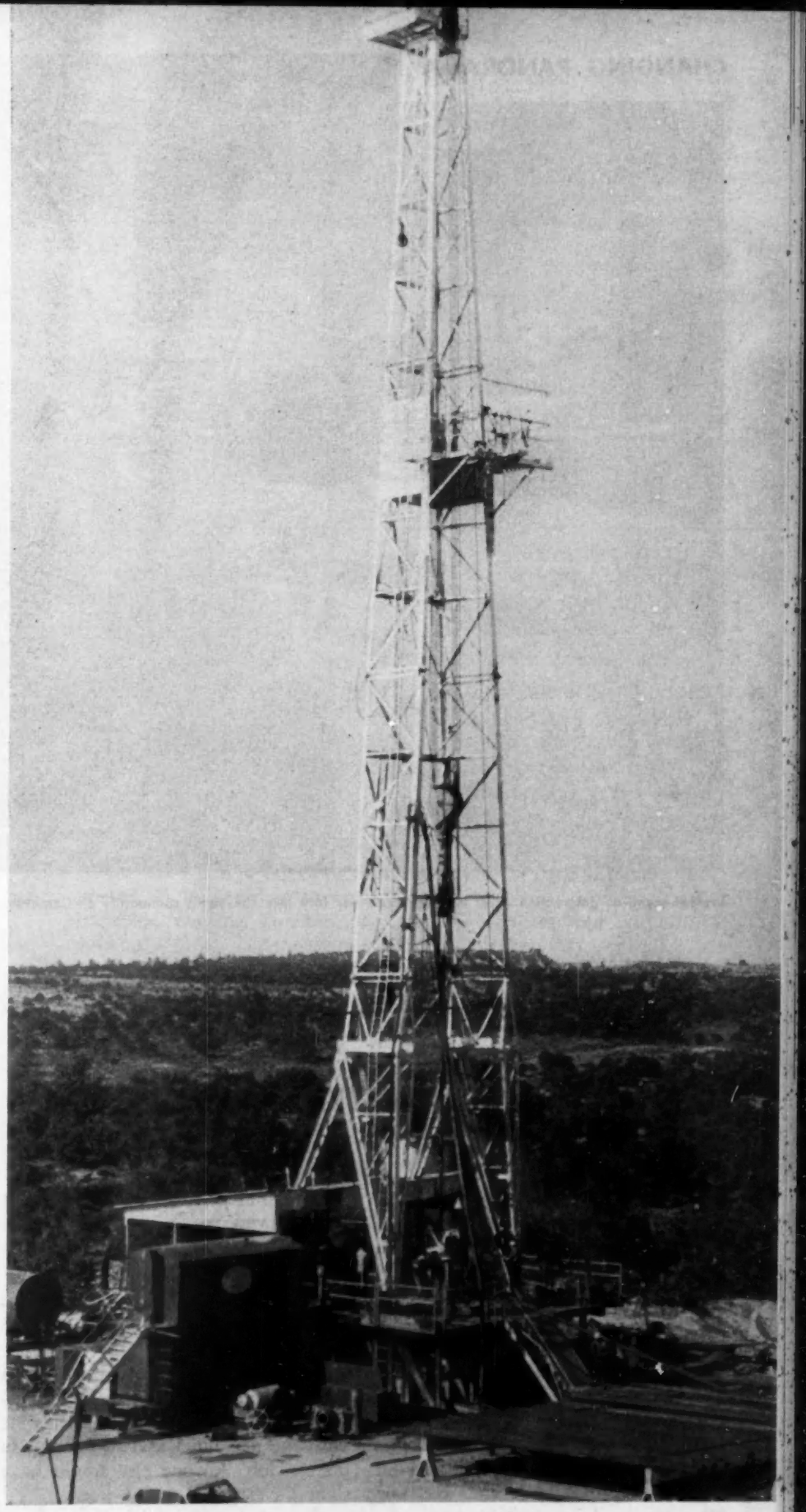
Although the present marketing facilities are entirely inadequate for the current production, relief is in sight. Two major pipe lines are planned that will provide more than adequate market for the potential oil production in both the San Juan and Paradox basins.

The incentives of good quality oil with good marketing facilities and producing without state prorationing more than offset the relatively high drilling costs and rather low reserves of the San Juan Basin.

It is difficult, if not impossible, to buy large blocks of acreage along trend within these fields. However, farmout type trades are available in which small blocks may be earned for drilling of wells.

The writer believes that the present trend discoveries will be extended and that new trends will be discovered with wildcat drilling in the near future. —**The End**

Turn to Page 63 For More About Four Corners Area



Typical drilling rig in Bisti area of San Juan Basin. Field produces 38- to 40-gravity crude from about 5200 feet. Initial production of typical well averages 250 barrels per day.

Typical scene of destruction after Audrey threw her fury into the small community of Cameron, La. Production tank at right has smashed a car.

Staff Report:

Oil and Hurricane Audrey

". . . It was just another job that had to be done. Anyone else would have done the same."

WORDS ARE inadequate to describe the work of oil industry personnel during and after Hurricane Audrey. So wide was its scope, the full story may never be known. Audrey, the first big blow of the 1957 hurricane season, formed in the Gulf of Mexico in late June and unleashed her full fury on the coastal area of Louisiana on June 27.

When contacted for information about damage and company contributions, many oil industry spokesmen emphatically requested that their companies names not be mentioned. The usual reply was:

"Why mention our name? It was merely a situation of our company being at the right place at the right time with the personnel and equipment to do the job. Anyone else would have done the same."

Nevertheless, the oil industry made such an outstanding contribution to ease suffering in the disaster area, some credit should be given even though the full story must remain incomplete and company names are withheld.

Plans Made Well in Advance. Shortly after word was received that Audrey was forming, volunteer groups met in the Cameron, La., area to outline a disaster plan. During two meetings on Tuesday, plans for a mutual aid radio system and the specific responsibilities of Civil Defense, Red Cross, Salvation Army and oil companies were firmed up.

On Thursday, June 27, Audrey hit. As soon as the havoc subsided enough to permit, the disaster plan was put into action. Following are but a few examples of the part oil people played in the disaster.

Everyone Pitched In. Shortly after the hurricane hit, an oil company employe—the assistant director of Civil

Defense for Calcasieu Parish (Lake Charles, La.)—took over for Cameron Parish until a Civil Defense group could be set up. Cameron had no Civil Defense organization at the time of the hurricane.

During the peak of the disaster, there were more than 1500 Civil Defense volunteers working in evacuation and clean up operations. About 60 percent were oil company personnel.

At one time there were 5000 Red Cross volunteers providing food, clothing, shelter and medical attention for disaster victims. Oil industry personnel made up a large percentage of the total.

One oil company employe coordinated transportation for Red Cross work. His wife is chief of Red Cross volunteers in the area.

. . . Then There Were Individuals. To describe all the examples of individual or group heroism would be impossible; there were too many. However, four examples merit special mention:

1. An oil company helicopter pilot took his two-place machine through high winds and torrential rains on a 52-hour rescue mission. He had seven hours sleep during the period.

The pilot set up air headquarters for the first rescue operations and coordinated helicopters and National Guard work. He landed at 90 percent of the houses in Cameron to locate stranded residents, then directed other craft to pick them up.

2. An oil company silk screen technician helped organize one of the most gruesome projects in the clean up operation. He coordinated a group of 38 men who used 15 air boats to bring out more than 115 bodies during a three-day period. One man during a two-hour period picked up 20 bodies. Most of the volunteers were oil company employes.

He summed up his experiences this way: "Most of the time we were working in five-foot water which came up to our chests when we got out of the boats. The bodies were usually stuck on anything that was still standing like fences, trees or poles. We would put them in an army blanket, tie knots at each end, and put them on the boats.

"The storm damage was unbelievable. The tidal surge must have been 30 feet above sea level in one place according to water marks on one telephone pole. Some houses were swept 16 miles into the marsh. There was hardly a house that didn't suffer 50 percent damage and most were a complete wreck."

3. Production personnel from one oil company took three boats down the Calcasieu Bayou. They came to a bridge that was out of commission, so they pulled the boats over the bridge with draglines. The group went on to Grand Cheniere where they rescued more than 100 people.

4. One oil company employe supervised operations of six air boats in the rescue operation. Even though all but one of the boats were lost, more than 100 lives were saved.

The Doors Were Open. Oil company cooperation during the disaster is aptly wrapped up in the following telegram sent Earl K. Long, governor of Louisiana:

"We hereby place at your disposal all manpower, equipment and facilities of ———— Oil Corporation that you may need in the emergency caused by the recent hurricane. You may contact any of our offices in the state."

Every available company helicopter, sea plane, boat, and marsh buggy was put into the disaster work with personnel to run them. Generators, trucks, pumps, bulldozers, medical supplies, portable shelters, everything and anything that was needed was flown or driven into the Cameron area. Several companies gave thousands of gallons of gasoline to power the rescue operations. One service station in the area was set up as central headquarters for the distribution of fuel.

One company used a DC-3 to fly Civil Defense personnel and police into the area.

Many sources say that the oil industry warning system was instrumental in evacuating thousands of people before the hurricane hit. Oil company mutual aid radio networks set up after regular communications failed were an instrumental factor in the rescue operations.

Generosity Was a Byword. A large number of oil companies, whether they had operations in the hurricane area or not, gave generous financial contributions. Of the $150,000 given to the Lake Charles Red Cross to date, more than half was contributed by the oil industry.

Employes of two companies were planning picnics during the week of the hurricane. They turned all their funds over to the Red Cross and Salvation Army. One check totaled $3000—the other $1000.

Companies with personnel in the area are paying up to half the financial loss their employes suffered. Several oil company personnel have been given extended leaves of absence with pay to take care of personal matters and to aid in clean up work.

Chances are that few people outside the oil industry will hear of any of these contributions. Even so, every oil company in the hurricane area performed a service of which it can be very proud. It was just another job that had to be done. —**The End**

Oil Industry Damage Tops $20 Million

Latest estimates of hurricane damage to offshore and onshore oil equipment and property total more than $20 million. The general damage picture looks like this:

- One offshore rig was lost. Value: More than $2 million.
- Approximately 15 oil companies reported damage ranging from $50,000 to $500,000 due to loss of marine shops, warehouses, offices and company houses in the Cameron area. One company reporting $200,000 damage lost a production platform, had eight others damaged and suffered considerable damage to equipment and property in and around Cameron.
- In the East and West Cote Blanche Bay areas, one company reported $5 million loss to crew quarters, power equipment, tank batteries, docking facilities, flow lines, walkways and gathering systems.
- Production loss due to shutdown will run into the millions of dollars.

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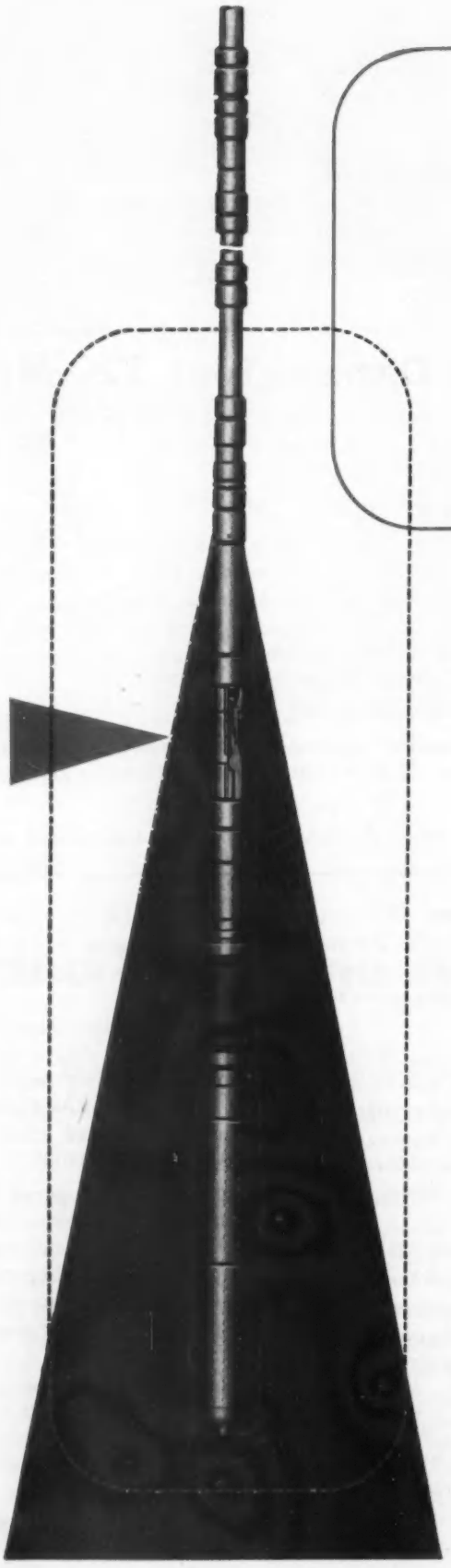

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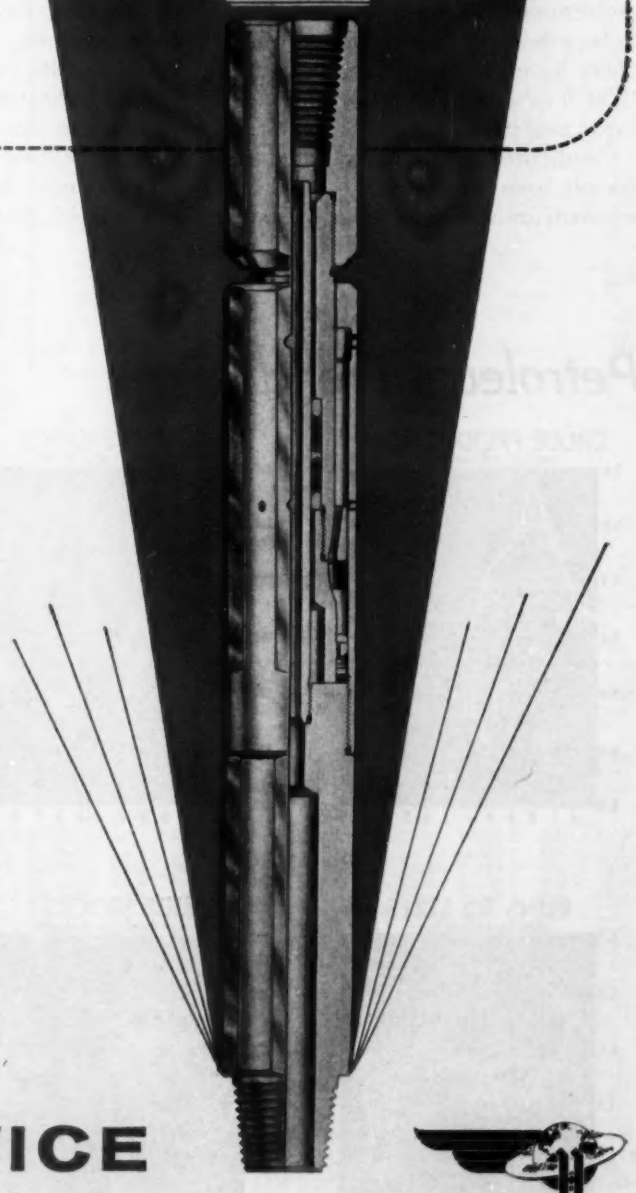

An upward pull against the weight of the fluid column causes the hydraulic system of the Jar to release suddenly, allowing the mandrel to move quickly. The tension in the pipe supplies the energy to cause the shoulder on the mandrel to deliver a sharp blow to the stuck packer or anchor. The Hydraulic Jar can be cocked and re-cocked again and again merely by slacking off pipe weight, as when the packer is set.

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By **RAY L. DUDLEY,** Publisher, and **WARREN L. BAKER,** Editor

U. S. Imports Are too High

Industry outlook is being aggravated by continued rise of imports to new peaks at a time when U. S. producers and refiners have sharply curtailed operations.

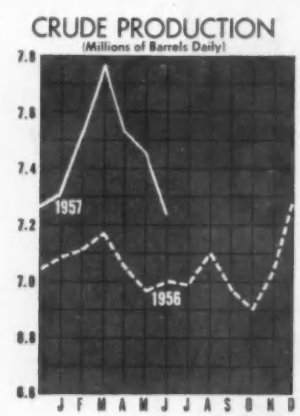
Imports need to be reduced if the problem of U. S. surplus oil supplies is to be solved. U. S. producers and refiners have curtailed their output to 1956 levels, but imports continue to rise to new peaks.

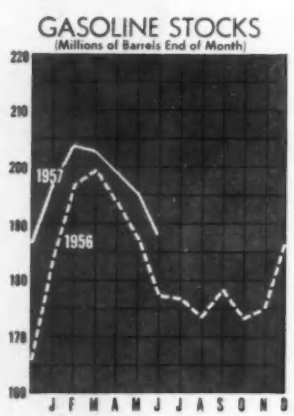
Crude production has been reduced sharply from a peak of 7,717,000 barrels daily in March to about 6,950,000 barrels daily in July. The latter is slightly less than the quantity produced in July, 1956. Crude runs to refinery stills probably will average around 7,900,000 barrels per day in July, which also is slightly under the quantity refined in July last year.

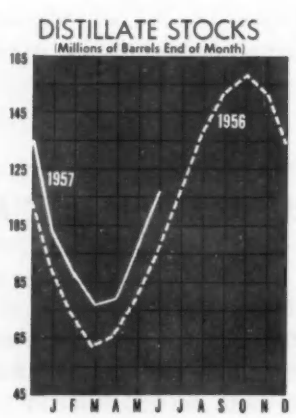
On the other hand, imports of crude and refined products in July are expected to average 1,600,000 barrels per day, 150,000 barrels greater than a year ago and 300,000 barrels above last April.

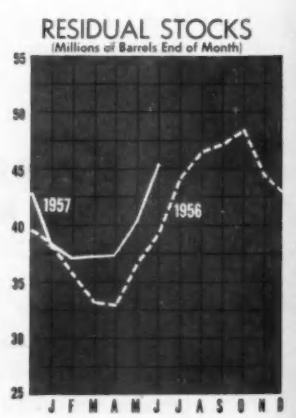
The California situation is being aggravated by higher imports to a greater degree than elsewhere in the U. S.

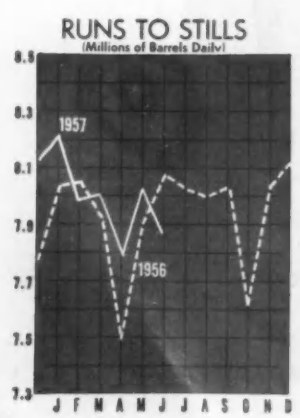
Petroleum Trends . . .

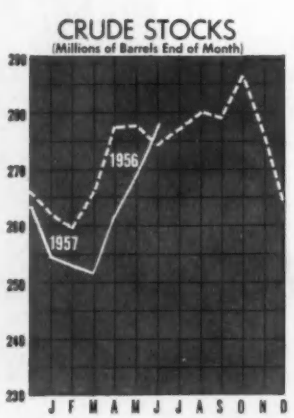


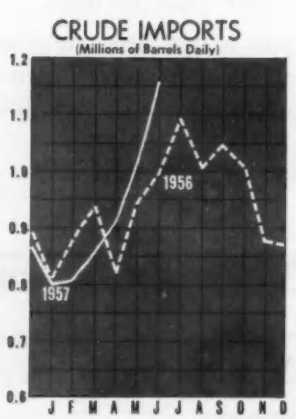


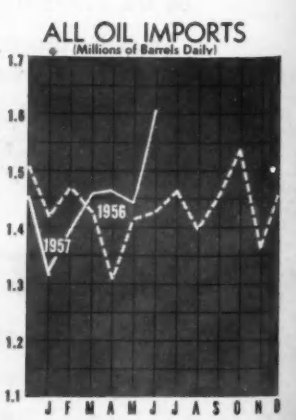












Latest figures available show imports of crude oil on the West Coast averaged 304,500 barrels daily during the four weeks ended July 12, an increase of 134,000 barrels over the corresponding period of 1956. No refined products were imported on the West Coast during this period.

Imports outside of California during the four weeks ended July 12 were only 30,000 barrels a day higher than in the corresponding period of 1956, with crude oil imports off 15,000 barrels and refined products up nearly 45,000 barrels daily.

Crude oil stocks have risen rapidly in recent months, but reduced allowables in July and August should retard the gain. By early July, U. S. crude oil stocks were 10½ million barrels higher than a month before, 25 million barrels greater than the end of March, 1957, and 5¾ million above one year ago. Obviously, these trends must be checked and reduced production allowables are a move in the right direction.

Distillate fuels are in surplus supply, and output of this product needs to be curtailed. On July 12 they totaled 125½ million barrels, 21 million above a year ago and 49 million barrels greater than at the end of March this year. This rate of increase must be checked at once.

Gasoline stocks have improved sharply in recent weeks. On July 12 U. S. gasoline stocks totaled 182 million barrels, only 3⅔ million barrels larger than at the corresponding time of the previous year. At the end of March they had been 7 million barrels above the preceding year.

The foregoing does not tell the full story on gasoline. Most of the increase in motor fuel inventories is located on the West Coast. Gasoline stocks outside of California were only 1 million barrels greater than a year ago on July 12.

The industry has an excellent opportunity to bring further improvement to the gasoline picture during the next few months. Gasoline stocks in 1956 dropped to 173 million barrels at the end of August, and were at practically this same level at the end of October. Hence, considerable improvement can be achieved in September and October, if production, refining operations, and import volumes are held to reasonable levels.

U. S. Crude Production by States

(THOUSANDS OF BARRELS)

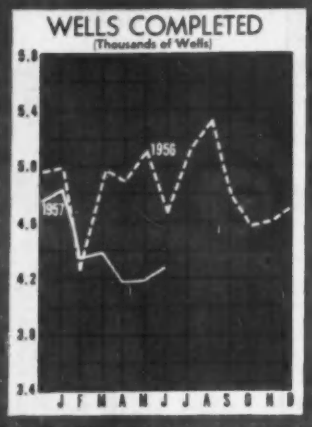
STATE or DISTRICT	DAILY AVERAGE PRODUCTION				TOTAL PRODUCTION FIRST SIX MONTHS		
	June, 1957	May, 1957	June, 1956	% Diff. 1957-1956	1957	1956	% Diff. 1957-1956
Alabama	12.3	11.9	8.6	+ 43.0	2,282	1,125	+102.8
Arkansas	85.9	85.4	79.4	+ 8.2	15,541	14,225	+ 9.3
California	926.1	928.5	961.5	— 3.7	168,692	175,935	— 4.1
Colorado	149.9	154.7	164.2	— 8.7	28,166	29,545	— 4.7
Florida	1.3	1.3	1.3	.....	228	244	— 6.6
Illinois	184.3	226.1	223.1	— 17.4	38,681	41,043	— 5.8
Indiana	29.3	32.3	31.3	— 6.4	6,250	5,294	+ 18.1
Kansas	343.8	344.8	344.8	— 0.3	60,446	62,110	— 2.3
Kentucky	42.1	47.4	48.1	— 12.5	8,317	8,729	— 4.7
Louisiana	879.3	924.2	804.1	+ 9.4	174,848	146,888	+ 19.0
North Louisiana	134.7	133.7	129.5	+ 4.0	24,785	23,152	+ 7.1
South Louisiana	744.6	790.5	674.6	+ 10.4	150,063	123,736	+ 21.3
Michigan	27.9	28.1	29.0	— 3.8	5,126	5,529	— 7.3
Mississippi	115.0	115.1	110.3	+ 4.3	20,713	20,118	+ 3.0
Missouri	0.1	0.2	0.1	.....	28	29	— 3.5
Montana	73.5	73.2	59.0	+ 24.6	13,005	10,277	+ 26.5
Nebraska	51.6	52.0	45.0	+ 14.7	9,184	7,650	+ 20.1
Nevada	0.1	0.1	0.2	— 50.0	16	37	— 56.8
New Mexico	258.4	266.8	234.2	+ 10.3	47,861	43,343	+ 10.4
Southeast New Mexico	254.3	263.5	230.5	+ 10.3	46,899	42,736	+ 9.7
Northwest New Mexico	4.1	3.3	3.7	+ 10.8	962	607	+ 58.5
New York	7.7	7.6	7.5	+ 2.7	1,352	1,370	— 1.3
North Dakota	37.7	36.9	36.2	+ 4.1	6,995	6,536	+ 7.0
Ohio	14.3	15.1	12.7	+ 12.6	2,530	2,295	+ 14.6
Oklahoma	580.4	606.6	579.8	+ 0.1	112,068	108,981	+ 2.8
Pennsylvania	24.0	22.5	23.5	+ 2.1	4,167	4,074	+ 2.3
South Dakota	0.1	0.1	0.1	.....	15	15	.....
Tennessee	0.1	0.1	0.1	.....	4	4	.....
Texas	3,080.2	3,159.9	2,995.1	+ 2.8	577,631	554,706	+ 4.1
Dist. 1: South Central	53.9	57.3	54.5	— 1.1	10,186	9,742	+ 4.6
Dist. 2: Middle Gulf	150.8	156.3	152.8	— 1.3	28,900	28,870	+ 0.1
Dist. 3: Upper Gulf	457.5	466.5	450.6	+ 1.5	84,510	82,773	+ 2.1
Dist. 4: Lower Gulf	203.2	237.3	236.6	— 1.4	44,077	44,812	— 1.7
Dist. 5: East Central	40.0	40.5	44.4	— 9.9	7,523	8,379	— 10.2
Dist. 6: Northeast	338.5	347.4	329.5	+ 2.7	64,136	63,243	+ 1.4
Dist. 7-B: North Central	165.9	167.2	153.1	+ 8.4	30,204	28,367	+ 6.5
Dist. 7-C: West Central	164.5	172.9	187.6	— 12.3	31,300	33,612	— 6.9
Dist. 8: West	1,160.7	1,186.0	1,036.1	+ 12.0	214,170	189,722	+ 12.9
Dist. 9: North	212.6	218.4	216.1	— 1.6	38,771	38,088	+ 1.8
Dist. 10: Panhandle	102.6	110.1	95.2	+ 7.8	18,961	17,104	+ 10.9
Utah	8.3	9.5	4.1	+ 2.4	1,841	901	+104.3
Virginia	0.1	0.1	.....	.....	8	5	+ 60.0
West Virginia	6.0	6.0	6.2	— 3.2	1,078	1,097	— 1.7
Wyoming	291.4	300.0	290.4	+ 0.3	53,439	52,062	+ 2.6
Total United States	7,231.2	7,456.5	7,099.9	+ 1.8	1,360,502	1,304,167	+ 4.3

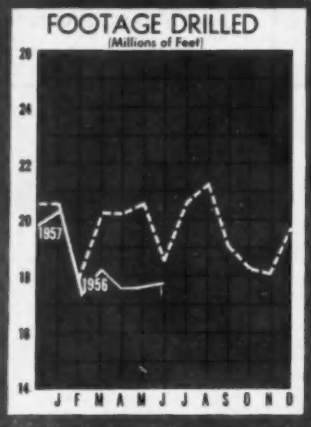
U. S. Crude Oil and Refined Product Trends

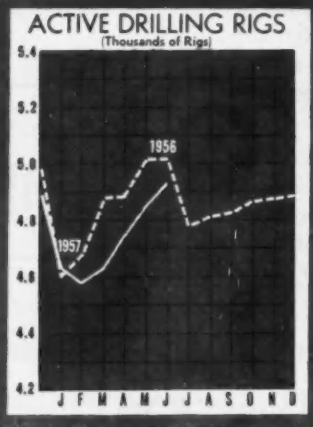
(THOUSANDS OF BARRELS)

MONTH	CRUDE OIL			GASOLINE		DISTILLATE FUEL		RESIDUAL FUEL		DAILY IMPORTS	
	Production Daily	Runs to Stills Daily	Stocks End of Month	Production Daily	Stocks End of Month	Production Daily	Stocks End of Month	Production Daily	Stocks End of Month	Crude Oil	Total Oils
1955:											
October	6,831	7,465	267,346	3,827	153,103	1,612	152,288	1,123	47,040	821	1,206
November	7,014	7,692	260,707	3,867	157,871	1,680	141,808	1,214	44,071	823	1,322
December	7,155	7,762	265,610	3,916	165,433	1,765	111,333	1,286	39,174	884	1,502
1956:											
January	7,199	8,023	261,592	3,927	183,905	1,923	86,141	1,344	38,247	805	1,422
February	7,208	8,047	259,504	3,854	196,092	1,918	71,335	1,286	35,673	878	1,472
March	7,278	7,914	265,683	3,829	199,698	1,808	60,846	1,213	32,984	934	1,425
April	7,146	7,487	277,121	3,646	193,299	1,713	63,571	1,130	32,740	815	1,305
May	7,064	7,896	277,497	3,859	186,673	1,667	75,928	1,149	36,607	938	1,416
June	7,100	8,071	274,491	3,976	177,076	1,755	93,758	1,098	39,073	987	1,426
July	7,090	8,014	277,008	3,975	176,536	1,767	115,787	1,066	43,958	1,084	1,463
August	7,195	7,995	279,944	4,037	172,939	1,839	137,905	1,091	46,617	1,001	1,399
September	7,054	8,024	278,791	3,991	177,974	1,845	150,411	1,062	47,342	1,043	1,452
October	6,966	7,608	286,560	3,773	172,798	1,772	158,871	1,082	48,400	1,004	1,541
November	7,139	8,031	275,995	3,913	174,808	1,841	151,517	1,182	44,590	871	1,362
December	7,377	8,141	266,014	4,039	187,271	1,981	133,981	1,288	44,491	873	1,471
1957:											
January	7,480	8,274	256,669	3,991	197,702	2,118	100,572	1,322	38,403	805	1,421
February	7,682	8,088	256,344	3,864	205,270	2,035	85,105	1,270	36,201	780	1,430
March	7,717	8,047	254,911	3,826	206,716	1,861	76,245	1,205	37,371	836	1,464
April	7,541	7,740	265,796	3,770	201,407	1,764	78,743	1,132	37,429	906	1,542
May	7,456	8,029	269,124	3,843	195,039	1,829	97,700	1,136	40,235	1,028	1,443
June	7,231	7,876	277,532	3,898	187,407	1,743	116,966	1,129	45,342	1,173	1,605
Week Ended:											
7-12-57	6,882	7,972	280,458	3,837	181,973	1,857	125,564	1,106	47,020	1,287	1,642
7-13-56	7,084	8,028	275,132	3,885	178,366	1,801	104,521	1,128	40,926	1,066	1,446

Drilling Activities . . .







Drilling Gains in June as Last Half Outlook Brightens

By CECIL W. SMITH, World Oil Staff

Although U. S. drilling activity turned upward during June, the year's volume fell farther behind last year's record high operations. During the first six months of this year, total wells drilled trailed the 1956 period's by 9.8 percent, while a month earlier the deficit had amounted to a slightly lower 9.6 percent. However, prospects for the last six months appear a little brighter. The slight upturn made in June is expected to be continued and increased in following months. That will result in substantially more wells completed in the last half than were recorded in the first six months. Which should bring the year's total wells to within a 5 percent reach of the peak drilled in 1956. That, of course, will be far short of the first-of-the-year's expectations, but it will be the development that began to come into focus shortly after the year began.

It was generally believed that the drilling slump that occurred during the latter four months of 1956 was principally the result of pipe shortages. One of the factors causing the slackening was scarcity of tubular goods, but it now appears that forces that now exist were also present, but not as clearly seen.

The 25 or 30 large or so-called major companies drill only slightly more than 20 percent of the nation's wells year-in and year-out. The remaining four-fifths are the responsibility of the thousands of smaller operators. Anything that upsets the stability of this large majority, can only seriously affect the overall national drilling program. It is this large element of the industry that has lowered its operations this year.

The reasons seem to be many, but most go back to the problem of justification, by these small operators, of pouring more money into ventures, whose payout possibilites could be very doubtful. In many cases, not only is justification hard to come by, but funds necessary to drill wells are lacking. It is not difficult to understand a small operator's hesitancy, or inability, to drill additional wells when he is not able to sell much of the oil that he is capable of producing from the wells that he already owns.

Many of the large companies are fulfilling their first-of-year drilling budgets, with some even increasing them at this time. There are some who are channeling increased amounts of their allocated funds into the more costly offshore wells, or into foreign fields. On the whole, it appears that the larger firms will drill at least as many domestic wells as they did last year.

In order to maintain the drilling volumes necessary to develop the nation's oil reserves, this great majority of smaller firms will have to be able to foresee possibility of a fair return on their investments either from increased markets or higher prices for their product.

Summary of U. S. Drilling Activity

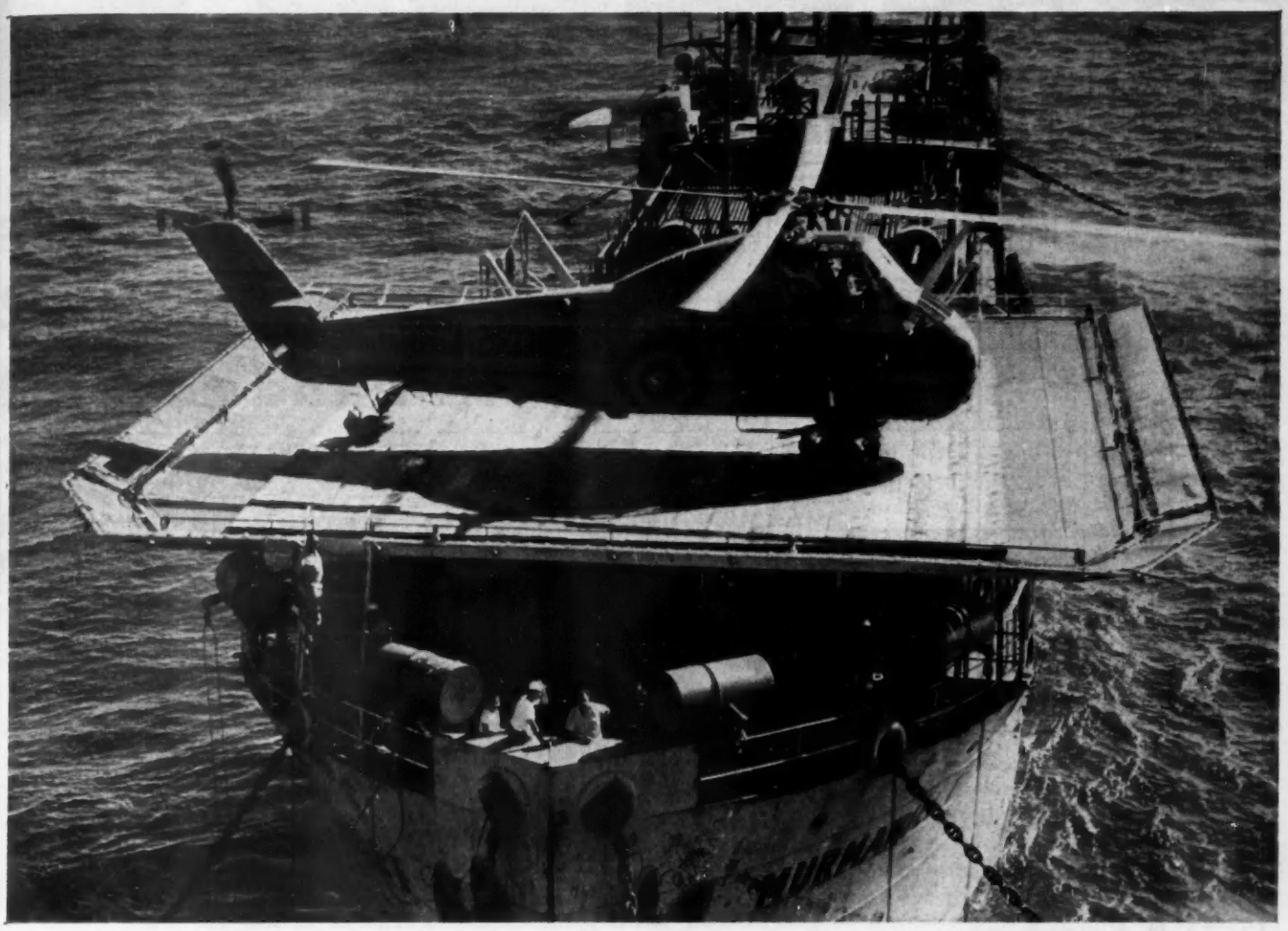
ITEM	June, 1957	May, 1957	SIX MONTHS January-June 1957	1956	Percent Diff.
New Wells Completed:					
Oil	2,083	2,205	13,804	15,503	— 11.0
Distillate	45	58	323	273	+ 18.3
Gas	332	303	1,780	1,936	— 8.1
Service	86	87	494	459	+ 7.6
Dry	1,738	1,497	9,675	10,723	— 9.8
Total Wells	4,284	4,150	26,076	28,894	— 9.8
Footage Drilled (Mln. of Feet)	17.7	17.6	108.5	117.5	— 7.7

Details on Page 60

Summary of U. S. Wildcat Drilling

ITEM	June*, 1957	May, 1957	SIX MONTHS January-June 1957	1956	Percent Diff.
New Field Discoveries:					
Oil	51	83	399	526	— 24.2
Distillate	5	14	64	52	+ 23.1
Gas	17	22	115	111	+ 3.6
Total Discoveries	73	119	578	689	— 16.1
Dry Wildcats	884	772	4,966	5,307	— 6.4
Total Wildcats	957	891	5,544	5,996	— 7.5
Percent Productive	7.6	13.4	10.4	11.5	.....
Percent Dry	92.4	86.6	89.6	88.5	.....

Details on Page 60



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For more information on Sikorsky helicopters, telephone or write Lee S. Johnson, general manager, Sikorsky Aircraft.

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U. S. Drilling Activity in June and First Six Months, 1957-1956

STATE or DISTRICT	TOTAL NEW WELLS COMPLETED AND FOOTAGE DRILLED: DETAILS FOR JUNE, 1957 — Oil	Dist.	Gas	Dry	Service Wells	TOTAL NEW WELLS — June, 1957	May, 1957	June, 1956	Total Footage June, 1957	DETAILS FOR JANUARY-JUNE — NEW WELLS — 1957	1956	Percent Diff.	FOOTAGE — 1957	1956
Alabama	6	....	....	5	....	11	10	10	84,111	62	46	+ 34.8	544,737	355,954
Arizona	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Arkansas	60	....	4	51	....	115	71	74	377,151	507	407	+ 24.6	1,503,967	1,285,802
California	129	....	9	52	....	190	195	155	823,749	1,089	1,061	+ 2.6	4,691,790	4,948,644
Colorado	9	....	6	58	....	73	55	97	383,223	402	651	— 38.3	2,096,170	3,421,102
Florida	....	....	....	....	....	....	....	....	....	6	6	....	40,312	35,002
Georgia	....	....	....	....	....	....	....	....	....	3	3	....	18,955	12,819
Idaho	....	....	....	....	....	....	....	....	....	1	1	....	3,947	4,528
Illinois	84	....	1	144	....	229	209	403	525,586	1,187	1,786	— 33.5	2,655,090	4,194,120
Indiana	17	....	1	32	....	50	81	52	84,103	323	303	+ 6.6	507,302	524,398
Kansas	136	....	39	173	8	356	318	374	1,269,724	2,023	2,363	— 14.4	7,206,396	8,340,112
Kentucky	45	....	17	99	4	165	144	151	226,711	744	857	— 13.2	1,114,985	1,237,578
Louisiana	166	12	27	130	....	335	309	294	2,606,263	1,790	1,780	+ 0.6	14,867,058	13,340,016
North Louisiana	59	....	10	54	....	123	91	133	465,130	622	710	— 12.4	2,321,280	2,574,641
South Louisiana	107	12	17	76	....	212	218	161	2,141,133	1,168	1,070	+ 9.2	12,545,778	10,765,375
* Gulf of Mexico	42	4	6	20	....	72	63	31	676,253	348	219	+ 58.9	3,270,605	2,007,166
Michigan	13	....	....	17	....	30	38	47	88,476	192	235	— 77.6	551,416	664,202
Mississippi	4	....	1	15	....	20	35	37	96,440	178	210	— 15.2	1,212,851	1,537,253
Missouri	....	....	....	....	....	....	1	2	....	1	17	— 4.1	370	18,095
Montana	22	....	1	23	....	46	28	38	220,369	178	195	— 8.7	957,469	1,001,198
Nebraska	28	....	1	55	....	84	85	98	492,643	423	512	— 17.4	2,499,749	2,928,492
Nevada	....	....	....	....	....	....	....	....	....	3	3	....	5,718	24,752
New Mexico	104	....	61	25	....	190	182	177	927,346	1,116	947	+ 17.8	5,092,215	4,313,410
New York	20	....	3	3	13	39	39	46	66,400	231	197	+ 17.3	394,100	277,200
North Dakota	9	....	....	9	....	18	22	20	137,025	132	139	— 5.0	920,677	1,073,481
Ohio	55	....	18	23	....	96	72	80	216,583	469	499	— 6.0	1,151,762	1,227,359
Oklahoma	189	3	16	133	20	361	363	604	1,288,165	2,809	4,120	— 31.8	10,272,372	14,833,743
Oregon	....	....	....	1	....	1	....	....	8,726	1	1	....	8,726	12,880
Pennsylvania	23	....	25	5	23	76	75	76	220,872	448	392	+ 14.3	1,289,086	1,107,266
South Dakota	....	....	....	2	....	2	5	1	11,812	25	4	— 75.0	95,533	28,436
Texas	920	25	64	613	17	1,639	1,698	1,749	6,905,689	11,011	11,292	— 2.5	46,022,793	47,410,810
Dist. 1: South Central	50	2	1	41	....	94	95	168	222,004	696	1,049	— 33.7	1,743,345	2,837,755
Dist. 2: Middle Gulf	15	7	5	35	....	62	75	64	376,611	363	427	— 15.0	2,276,055	2,657,683
Dist. 3: Upper Gulf	66	7	6	57	....	136	137	132	876,823	876	887	— 1.3	5,933,451	5,898,440
* Gulf of Mexico	....	....	....	....	....	....	....	....	....	5	4	+ 25.0	37,935	40,088
Dist. 4: Lower Gulf-S.W.	42	4	4	67	....	117	131	150	602,197	720	744	— 3.2	3,807,170	3,926,074
* Gulf of Mexico	1	1	....	....	....	2	1	....	17,814	10	6	+ 66.7	95,721	60,723
Dist. 5: East Central	....	....	1	10	....	11	7	13	35,467	78	122	— 36.1	347,122	413,085
Dist. 6: Northeast	45	3	4	38	....	90	81	71	493,897	546	449	+ 21.6	2,988,969	2,353,282
Dist. 7-B: North Central	79	....	2	90	....	171	220	247	591,498	1,331	1,613	— 17.5	4,526,123	5,608,923
Dist. 7-C: West Central	51	....	4	40	....	95	104	86	413,498	621	636	— 2.4	2,716,61	2,953,828
Dist. 8: West	317	....	4	52	6	379	423	318	1,849,367	2,521	2,024	+ 24.6	12,310,404	10,262,966
Dist. 9: North	176	2	8	168	11	365	323	382	974,533	2,560	2,673	— 4.2	6,606,850	7,971,670
Dist. 10: Panhandle	79	....	25	15	....	119	102	118	469,794	699	668	+ 4.6	2,766,690	2,527,104
Utah	9	....	....	16	....	25	18	8	142,690	92	72	+ 27.8	541,169	338,641
Washington	....	*	....	1	....	1	....	....	6,023	2	1	+100.0	12,003	7,493
West Virginia	8	5	35	9	....	57	44	58	156,466	284	350	— 18.9	778,738	921,950
Wyoming	27	....	3	44	1	75	53	65	321,764	344	444	— 22.5	1,473,976	2,080,138
Total United States	2,083	45	332	1,738	86	4,284	4,150	4,716	17,688,110	26,076	28,894	— 9.8	108,531,432	117,506,874
Total Western Canada	223	....	16	119	1	359	210	174	1,671,420	1,456	1,142	+ 27.5	6,876,323	5,484,674

STATE or DISTRICT	WILDCAT DRILLING IN JUNE AND FIRST SIX MONTHS, 1957-1956: DETAILS FOR JUNE, 1957 — Oil	Dist.	Gas	Dry	Total Wildcats	DETAILS FOR JANUARY-JUNE — Oil	Dist.	Gas	Dry	TOTAL WILDCATS — 1957	1956	DRILLING RIGS IN OPERATION — June 30, 1957	May 31, 1957	June 30 1956
Alabama	....	....	....	5	5	....	....	1	21	22	16	11	20	12
Arizona	....	....	....	....	....	....	....	....	....	....	....	5	3	2
Arkansas	4	....	....	21	21	....	....	....	69	73	70	82	85	53
California	5	....	3	31	31	5	....	3	173	181	122	184	196	200
Colorado	9	....	7	46	48	9	....	7	230	246	311	59	48	78
Florida	....	....	....	....	....	....	....	....	6	6	6	1	1	1
Georgia	....	....	....	....	....	....	....	....	3	3	3	1	....	1
Idaho	....	....	....	....	....	....	....	....	1	1	1	....	....	1
Illinois	1	....	....	73	74	7	....	1	346	354	463	254	239	331
Indiana	1	....	....	11	11	1	....	....	86	87	80	106	101	91
Kansas	9	....	4	75	88	52	....	17	409	478	616	584	545	475
Kentucky	2	....	....	12	14	10	....	....	49	59	70	123	132	134
Louisiana	1	1	2	53	57	14	23	8	244	289	291	396	435	427
North Louisiana	....	....	....	18	18	3	2	2	70	77	90	68	77	85
South Louisiana	1	1	2	35	39	11	21	6	174	212	201	328	358	342
* Gulf of Mexico	....	....	1	5	6	5	4	2	29	40	32	94	96	75
Michigan	....	....	....	11	11	7	....	....	73	80	75	77	74	69
Mississippi	1	....	....	18	19	7	....	....	88	95	82	39	41	30
Missouri	....	....	....	....	....	....	....	....	2	2	11	1	1	1
Montana	....	....	....	15	15	2	....	1	52	55	63	52	52	46
Nebraska	4	....	....	39	43	19	....	1	200	220	253	49	46	33
Nevada	....	....	....	....	....	....	....	....	3	3	1	1	2	2
New Mexico	2	....	....	12	14	25	....	3	118	146	119	186	159	210
New York	....	....	....	....	....	....	....	....	....	....	....	58	59	67
North Dakota	6	....	....	7	7	6	....	....	50	56	40	28	26	21
Ohio	....	....	....	....	....	....	....	....	3	3	3	215	206	209
Oklahoma	5	1	1	32	39	32	6	11	265	314	431	564	571	647
Oregon	....	....	....	1	1	....	....	....	1	1	1	....	1	....
Pennsylvania	....	....	3	1	4	....	....	18	7	25	....	166	172	143
South Dakota	....	....	....	2	2	....	....	....	24	24	4	3	1	4
Texas	21	3	6	382	412	185	35	35	2,301	2,556	2,699	1,349	1,354	1,413
Dist. 1: South Central	1	....	....	26	27	7	1	....	188	196	259	47	45	64
Dist. 2: Middle Gulf	....	1	....	27	28	3	8	8	112	131	137	45	42	45
Dist. 3: Upper Gulf	3	....	....	35	38	14	6	1	214	235	227	129	142	147
* Gulf of Mexico	....	....	....	....	....	1	....	....	2	3	2	....	1	3
Dist. 4: Lower Gulf-S.W.	2	1	....	33	36	10	6	1	207	224	235	87	77	78
* Gulf of Mexico	....	....	....	....	....	....	....	....	....	....	1	3	4	2
Dist. 5: East Central	....	....	1	8	9	1	1	1	55	58	63	8	5	7
Dist. 6: Northeast	1	1	1	23	26	2	2	3	119	126	127	74	75	67
Dist. 7-B: North Central	3	....	2	61	66	45	....	6	427	478	619	121	111	140
Dist. 7-C: West Central	5	....	1	33	39	26	....	5	172	203	155	95	93	136
Dist. 8: West	3	....	....	33	36	34	1	2	212	249	272	390	398	357
Dist. 9: North	3	....	....	94	97	37	....	4	552	593	549	241	226	257
Dist. 10: Panhandle	....	....	1	9	10	6	10	4	43	63	56	117	135	115
Utah	2	....	....	9	11	6	....	2	39	47	51	54	51	29
Washington	....	....	....	1	1	....	....	....	2	2	1	1	....	....
West Virginia	....	....	1	2	3	....	....	5	5	10	....	175	170	190
Wyoming	1	....	....	25	26	8	....	2	96	106	113	96	87	99
Total United States	51	5	17	884	957	399	64	115	4,966	5,544	5,996	4,930	4,868	5,019
Total Western Canada	....	....	....	....	....	....	....	....	....	....	....	219	241	211

* Gulf of Mexico wells are included in their respective district totals.

SPECIAL REPORT: Four Corners Area

Structures of Southwest Paradox Basin

- **Twelve new oil and gas producing structures have been opened in past two years in basin 350 miles long and 175 miles wide.**
- **Petroleum reserves proved by development so far are estimated at 250 million barrels.**

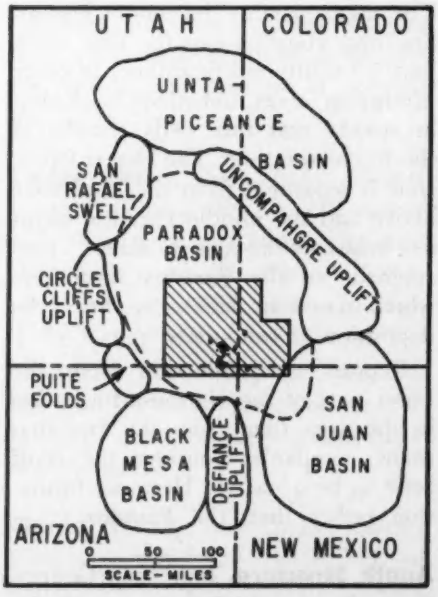
By **MARVIN L. MATHENY**
El Paso Natural Gas Company
Farmington, N. M.

DURING THE past two years 12 new oil and gas producing structures have been discovered in the Southwest Paradox basin. Petroleum reserves of the area proved by development to date are roughly estimated at 250 million barrels. Exploration drilling is being continued on a major scale. These recent discoveries have brought the Paradox basin to its present rating as one of the major oil and gas producing areas of the Rocky Mountain region.

All of the present production in the area is located on structures. The purpose of this article is to briefly discuss some of the structures and their relationship to producing horizons of Paleozoic strata.

The Paradox basin is an elongate, northwest trending sedimentary basin of Pennsylvanian age. (See Index Map.) It encompasses all of southeast Utah, the extreme northeast corner of Arizona, the northwest corner of New Mexico, and the southwest corner of Colorado. It is approximately 350 miles long and 175 miles wide. Major tectonic features within the Colorado Plateau physiographic province which border and define the geographic limits of the basin are: Uinta Basin on the north, San Rafael swell on the northwest, Circle Cliffs uplift and Piute folds on the west, Black Mesa basin on the southwest, Defiance uplift on the south, San Juan basin on the southeast, San Juan uplift on the east, and Uncompahgre uplift on the northeast. Lithologically, the areal extent of the basin is defined as the area covered by the evaporite facies of the Paradox formation of Pennsylvanian age.

Physiographic features of note in the area are: (1) the laccolithic domes (La Sal, Ute, Carrizo and Abajo Mountains); (2) Comb Ridge, the sharply folded eastern flank of the Monument upwarp; (3) rugged and picturesque outcrops of the Monument Valley and San Juan Canyon areas.



Index Map

Regional Structure. The only major structure in the area is the Monument upwarp, a north-trending structure approximately 110 miles long and 60 miles wide. It is asymmetrical to the east, and contains many minor north-trending folds, some in an en echelon arrangement. The upwarp and its smaller structures are considered to be essentially Laramide in age. None of the structures associated with the upwarp has produced commercial quantities of oil or gas to date.

Structural configuration of the area during Paleozoic time, of prime interest to the petroleum geologist, is very often difficult to determine. Laramide and later deformation partially masks the Paleozoic structures. As a result of this admixing of structures of different ages within a relatively small area, exploration based on drilling surface structures has not been entirely successful. Recent application of the effects of Laramide and later deformation to the Paleozoic tectonics of the area has resulted in a much higher discovery ratio in drilling surface structures.

Fields on Northwest-Trending Structures. Several general conclusions are suggested by a study of various structures in the area: (1) the majority of the north-trending structures are associated with Laramide deformation and are not productive. (2) Most of the northwest-trending structures are associated with Paleozoic deformation, and many were rejuvenated during Laramide deformation. (3) Most of the oil and gas fields and pools are located on northwest-trending structures. (4) Many of the structures have porous and permeable strata on the flanks which become tight and dense updip and on the structural crest. A few of the recent discoveries have been on the flanks of structures previously condemned because of crestal wells which lacked permeability in the potential

producing horizons. (5) In many cases structures with closure at depth have the surface appearance of a slight nose.

The rejuvenation of Paleozoic structures is fortunately very common. To the author's knowledge, all of the producing structures of the area can be mapped at the surface where a mappable outcrop is present. The assumed northwest trend of the older structures roughly parallels the Pennsylvanian sedimentary trough of the basin and the Uncompahgre uplift. This trend is believed by many geologists to have been derived from compactional forces caused by sedimentary loading of the basin proper and clastic dumping adjacent to the uplift.

Subsurface mapping on the top of the Paradox formation shows regional dip to be eastward from Comb ridge, northward from the Defiance uplift, and southward from the Dove Creek area. This places many of the producing structures of the area in a regional low, emphasizing the importance of local structures.

Production from Paradox. Petroleum production of the area has been almost entirely from the Paradox formation, as defined by the author. So it is felt that a brief discussion of stratigraphy limited to this formation will best serve the purpose of this article.

The Paradox formation, by general definition, consists of the evaporites below the normal marine strata of the upper Hermosa formation and above the normal marine strata of the Pinkerton Trail (lower Hermosa) formation. The author prefers to include also the porous carbonates which are edge facies of the evaporites. The formation is subdivided into upper, middle and lower members, as illustrated in the diagramatic cross-section.

On the basin edge the upper member consists of carbonates which are equivalent to evaporites in the more central part of the basin. Of the three members, evaporites show the smallest areal extent in this member. Only in local areas does salt exist.

The middle member has the greatest areal extent and thickness of the three members. Basinward it consists almost entirely of salt. The salt changes shelfward to anhydrite and gypsum, to primary carbonates, to the porous carbonates comprising the edge facies.

The lower member consists of salt in the central basin area which goes through the lithofacies changes to the porous carbonates of the edge area.

Black shales, interbedded with the sediments mentioned above, are fairly continuous throughout most of the basin and serve as markers for correlation purposes.

Evaporites of the Paradox formation are cyclic, demonstrating both lateral and vertical facies change in each individual cycle and in the formation as a complete major cyclic unit.

Upper Paradox Chief Pay. The porous carbonates of the evaporite edge facies are the principle reservoir beds of the southwest Paradox basin. Middle and lower Paradox strata have yielded commercial production on only a few structures. Most of the production of the area to date has been found in the upper member. Further subdivision of the upper member is considered necessary because of substantial production found in two lentils of the member. Zone names have been assigned and published by workers in the area, and will be used in this article.

The uppermost of these zones has been designated the Bluff zone. It consists of limestone, which sometimes produces oil and gas from a porous interval near the bottom.

The lowermost, designated Desert Creek zone, has in some areas developed porosity in excess of 90 feet. In the Aneth Field, the Desert Creek zone is approximately 170 feet thick and consists entirely of carbonates. The upper part of the zone is crystalline and vuggy dolomite. The lower part is fossiliferous limestone. In other producing areas, anhydrite is present in streaks and thin beds, usually at the top of the zone. The Desert Creek zone is separated from the Bluff zone above and the middle Paradox member below by black sooty shales, characteristic of the Paradox formation, which represent breaks in the cyclic deposition of evaporites.

Reports of production from the lower part of the Hermosa formation in the area stem from the fact that many companies consider the Bluff zone to be a part of Hermosa formation rather than the Paradox.

Aneth Structure. San Juan County, Utah, Township 40 S, Range 23, 24, 25 E. A west-northwest trending anticline, with approximately 130 feet of closure at depth. It is separated on the northwest from the Bluff anticline by a small saddle. Surface outcrops are Dakota and Morrison formations of Jurassic age. The south flank dips gradually, but the north flank is rather steep. Both the Bluff and the Desert Creek zones produce on the structure. A few wells have been duly-completed. Production in the Bluff zone is limited to the edges of the structure. The structure has been tested through Mississippian strata to 7402 feet, with the only major shows of oil and gas reported being in the upper member of the Paradox formation at approximately 5700 feet. Field limits have been established in only a few places. In these wells the limiting factors have been either formation water or lack of permeability. The discovery well, the Texas Company's Navajo 1-C, was drilled in 1956.

Initial potentials in the field range from 100 to 3600 barrels oil per day, with an average gas-oil ratio of approximately 700:1. Formation pressures for the field are approximately 2200 pounds per square inch. It has been suggested that the drive for the field is of the solution gas type. But sufficient data to substantiate this conclusion is not available. Approximately 45 producing wells have been completed in the field to date.

Barker Dome. San Juan County, New Mexico, and La Plata County, Colorado, Township 32N-Range 14W. A northeast trending asymmetrical dome, with approximately 375 feet of surface closure. The surface outcrop is the Mesaverde formation of Cretaceous age. The structure was drilled to 9466 feet in the Devonian Elbert formation. It produced inflammable gas from the Dakota formation of Cretaceous age at about 2500 feet and the Paradox formation of Pennsylvanian age at about 9,000 feet. The Dakota reservoir is now depleted. Faulting occurs on the crest and on the southeast flank.

Initial potentials of Dakota wells ranged from approximately 5 to 30 million cubic feet per day. Production was from sandstones with net pays up to 100 feet, average porosity of 14 percent, permeabilities up to 1500 millidarcys, and formation pressures of approximately 600 psi.

Paradox production is from the up-

per and lower members. Porous and fractured carbonates yield initial potentials up to 145 MMCFPD. The major production is sour gas from the lower member which must be treated. Sweet gas is produced from the upper member. A water-gas contact limits the producing area of the field. Average porosity is 3.5 percent, permeabilities are up to 30 millidarcys, and formation pressures are approximately 2900 psi.

Beef Basin. San Juan County, Utah, Township 32S, Range 19E.—A northwest trending anticline with a small fault crossing the axis on the northwest flank. The surface outcrop is Cedar Mesa formation of Permian age. Surface closure on the structure is approximately 150 feet. The structure has been tested to Cambrian strata in 1957 to 4945 feet. No major shows of oil or gas were encountered.

Bita Peak. Apache County, Arizona, Township 41N, R 31E. A northeast trending surface nose with slight closure at depth. The Morrison formation of Jurassic age outcrops at the surface. A test through the Paradox formation in 1956 to 5648 feet by El Paso Natural Gas Company's Bita Peak 1 resulted in production of 21 MMcfpd of inflammable gas from the Bluff zone at about 5200 feet. Shows of oil and gas were encountered in middle and lower Paradox members. Formation-pressure of the discovery well was 1850 psi.

Bluff. San Juan County, Utah, Township 39S, Range 23E. A northwest trending anticline with approximately 50 feet of surface closure. Sandstones of the Cretaceous Dakota formation form the surface outcrop. The structure was drilled in 1952 to 8762 feet in Pre-Cambrian strata. It produces oil and gas from both the Bluff and Desert Creek zones on the southeast flank. Major shows of oil and noninflammable gas were encountered in Mississippian strata. The initial test well was located on the crest of the structure. It lacked permeability in the production zones and was abandoned. Initial potential on the discovery well, Shell's Bluff 3, in 1956 was: Bluff zone-168 BOPD with a formation pressure of 1900 psi; Desert Creek zone-144 BOPD with a formation pressure of 2200 psi.

Boulder Knoll. San Juan County, Utah, Township 34S, Range 25 and 26E. A northwest trending anticline with approximately 100 feet of surface closure. The Dakota formation outcrops at the surface. A test to 8678 feet to Devonian strata encountered non-inflammable gas in Mississippian and Devonian strata.

Boundary Butte. San Juan County, Utah, Township 43S, Range 22E, and Apache County, Arizona, Township 41N, Range 28E. An accurate asymmetrical anticline containing three structural highs. The steepest dips are on the south and west sides with the concavity toward the northeast. From east to west, respectively, the structural highs are called East Boundary Butte, Boundary Butte and North Boundary Butte. The structure has been drilled to Devonian strata at 6490 feet. Maximum surface closure on the central high is approximately 450 feet. The surface outcrop consists of rocks of the Glen Canyon group of Jurassic age.

East and North Boundary Butte produce oil and gas from both the upper and lower members of the Paradox formation. Boundary Butte produces gas from the upper member and oil and gas from the middle and lower members, plus a small amount of oil from the DeChelly sandstone of Permian age. The Permian production is located on the crest of the structure at approximately 1500 feet. An oil-water contact defines the field limits.

The producing area of the Paradox formation is governed by a very erratic oil-water contact. There are nine wells producing from the Paradox formation on the structure to date from an average depth of about 5000 feet. Formation pressure is approximately 1400 psi.

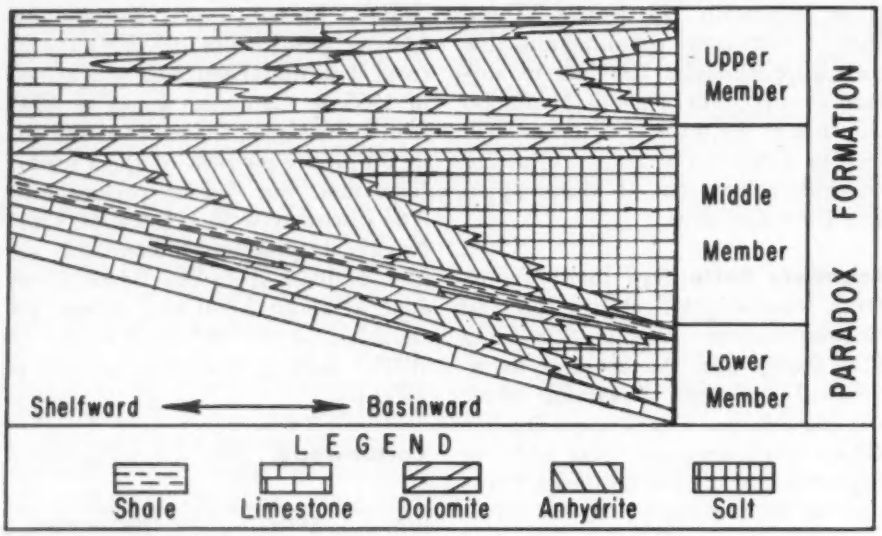
Cedar Mesa. San Juan County, Utah, Township 39, 40, 41S, Range 18E. A sinuous north trending anticline with approximately 100 feet of surface closure. The surface outcrop is the Cedar Mesa formation of Permian age. The structure has been tested to Pre-Cambrian strata in 1954 to 6490 feet with no appreciable shows of oil or gas.

Chinle Wash. San Juan County, Utah, Township 43S, Range 21E—A domelike northwest trending anticline with approximately 200 feet of surface closure. Jurassic rocks of the Glen Canyon group form the surface outcrop. The initial test well was drilled in 1955 to Cambrian strata to 6945 feet. It had good shows of oil and gas in the upper member of the Paradox formation, but lacked permeability. The discovery well, U.S.S.R.M. Ohio Navajo 1, produces inflammable gas and distillate from the Desert Creek zone at about 5,000 feet. It was potentialed at 10 MMCFPD and 24 BDPD, with a formation pressure of 1350 psi.

Cottonwood. San Juan County,

PERIOD	EPOCH	GRP.–FORMATION–MEMBER
TERT.	Eocene	
	Paleocene	
CRETACEOUS	Montanan	Lewis (sh.)
	Coloradan	Mesa-Verde: Cliff House (ss); Menefee (coal, ss, sh); Point Lookout (ss)
		Mancos: Upper Mancos Member (sh); Gallup Member (ss); Sanostee Member (sdy ls); L. Mancos Member (sh); Greenhorn Member (ls); Graneros Member (sh)
	Dakotan	Dakota (ss)
	Lower	
JURASSIC	Upper	Morrison: Brushy Basin Mem. (sh); Westwater Member (ss); Recapture Member (sh); Salt Wash Member (ss)
	Middle	Gr. San Rafael: Bluff (ss); Summerville (sh); Entrada (ss); Carmel (sh)
	Lower	Glen Canyon Gr.: Navajo (ss); Kayenta (sh)
TRIASSIC	Upper	Wingate (ss); Chinle (sh); Shinarump (cgl)
	Middle	
	Lower	Moenkopi (sh)
PERMIAN	Ochoa	
	Guadalupe	
	Leonard	Hoskinnini (sh); DeChelly (ss); Organ Rock (sh)
	Wolfcamp	Cedar Mesa (ss); Halgaito (sh)
PENNSYLVANIAN	Virgil	Rico (ls, sh)
	Missouri	Hermosa (ls)
	Des Moines	Paradox; Pinkerton Trail (ls)
	Atoka	Molas (sh)
	Morrow	
MISS.	Chester	
	Meramec	Leadville (ls)
	Osage	
	Kinderhook	
DEVONIAN	Upper	Ouray (ls); Elbert: U. Elbert (dol); McCracken Mem. (ss)
		Aneth
	Middle	
	Lower	
O S		
CAMBRIAN	Upper	Lynch (dol)
	Middle	Bowman (ls); Hartman (ls)
	Lower	Ophir (sh); Tintic (qtzte)
PRE–CAMBRIAN		

Generalized Nomenclature Chart of Southwest Paradox Basin



Diagrammatic Cross-Section of Southwestern edge of Paradox Basin.

Utah, Township 38S, Range 22E. A small northwest trending anticline with approximately 50 feet of surface closure. The surface outcrop is Dakota formation of Cretaceous age. A test of the structure, drilled in 1956 to Paradox salt at 6548 feet, encountered salt water and shows of oil in the Bluff zone at about 6300 feet.

Desert Creek. San Juan County, Utah, Township 41 and 42S, Range 23E. A north trending anticline with a probable fault paralleling the axis. Maximum closure at depth is estimated at 400 feet. The Morrison formation of Jurassic age forms the surface outcrop. The initial test well was drilled in 1954 to 6700 feet to Cambrian strata. It was located on the crest of the structure west of the probable fault. Shell's Desert Creek 2, the discovery well, was drilled in 1954 and was located northeast of the initial test. It produces oil and gas from the Desert Creek zone of the Paradox formation at about 5200 feet. Four wells have been drilled on the structure to date, two producers and two dry holes. The dry holes lacked permeability in the pay zone. Initial potential of the discovery well was 248 bopd, with a formation pressure of 2000 psi.

Dove Creek. Montezuma County, Colorado, Township 38, 39N, Range 18, 19, 20W. A northwest trending anticline with approximately 50 feet of surface closure. The Dakota formation of Cretaceous age forms the surface outcrop. The discovery well, Western Natural's Driscoll 1, drilled in 1948, was potentialed at 500 bpd and 5 MMcf gas. It produces from the Desert Creek zone at about 5900 feet, and was drilled to 8286 feet in Mississippian rocks. Porosity and permeability are extremely variable on the structure. Of the nine wells drilled, two produce oil and one produces gas and distillate. Producing wells on the structure have suffered a rapid pressure decline.

East Aneth. San Juan County, Utah, Township 41S, Range 26E. A small west-northwest trending anticline with approximately 75 feet of surface closure. The Dakota formation of Cretaceous age forms the surface outcrop. The initial test well on the structure was drilled to the Paradox salt, encountering salt water in both the Bluff and Desert Creek zones at about 6000 feet.

Egnar-Glade. Dolores County, Colorado, Township 40, 41, 42N, Range 16, 17, 18W—A large northwest trending anticline with a surface closure of 400 feet. Cretaceous strata of the Dakota formation from the surface outcrop. The test well, drilled in 1948, was bottomed in igneous rock at 7680 feet which probably was a tertiary sill. No shows of oil or gas were encountered.

Elk Ridge. San Juan County, Utah, Township 34, 35S, Range 18, 19E. A large north trending anticline in rough alignment with the Cedar Mesa and Halgaito anticlines to the south. Pennsylvanian strata of the Hermosa formation outcrop on the surface. Maximum closure at the surface is approximately 1,000 feet. The structure was drilled in 1927 to 4422 feet to Pre-Cambrian rocks, with gas shows in the Paradox formation at about 1500 feet.

A much smaller structure, East Elk Ridge anticline is located off the northeast flank. This smaller structure was tested in 1956 to 4218 feet in Cambrian strata, with no appreciable shows of oil or gas.

Fish Creek. San Juan County, Utah, Township 38S, Range 20E. A small domelike northwest trending anticline with a surface closure of approximately 75 feet. Permian rocks of the Cedar Mesa formation are exposed at the surface. The structure has been tested to Devonian strata (1954) to 4840 feet. Shows of oil and gas were encountered in the Paradox formation at about 2300 feet.

Gypsum Creek. Apache County, Arizona, Township 41N, Range 23E. A small northeast trending anticline with the Permian Cutler group exposed at the surface. The test well was drilled in 1924 to 2081 feet to Mississippian strata. Shows of gas were encountered in the Rico formation of Permo-Pennsylvanian age at 500 feet.

About the Author

MARVIN L. MATHENY has previously published articles in local geological society guidebooks. After two years with the US Navy as an LTJG, Matheny was employed by El Paso Natural Gas Company in 1954, his present employer. He received his B.S. in geology with a minor in petroleum engineering and one in naval science from the University of New Mexico in 1952. Matheny is originally from Kermit and Borger, Texas.

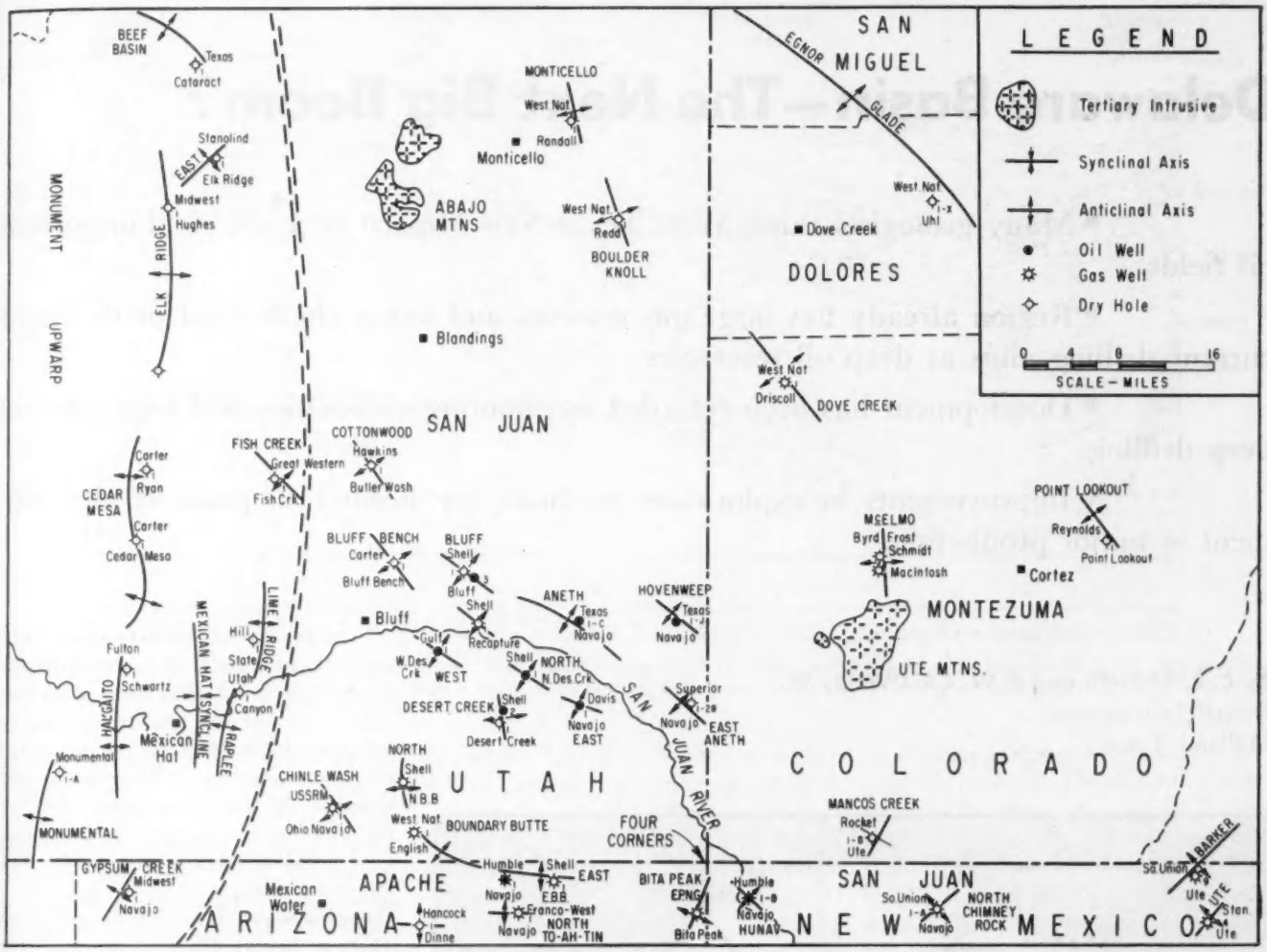


FIGURE 1—Map of Southwestern Paradox Basin showing structural trends and key wells.

Halgaito. San Juan County, Utah, Township 42S—Range 17E. A north trending anticline with approximately 500 feet of surface closure. The Cedar Mesa formation of Permian age forms the surface outcrop. The structure has been tested through the Paradox formation to about 2000 feet with no appreciable shows of oil or gas.

Hovenweep. San Juan County, Utah, Township 39, 40S, Range 25, 26E. A small northwest trending anticline with a surface closure of approximately 50 feet. The Dakota formation of Cretaceous age outcrops on the surface. The structure produces oil and gas from the Bluff zone at about 5600 feet. Field limits, where established, are determined by an oil-water contact. Initial potential of the discovery well, Texas Company's Navajo 1-J, drilled in 1956, was 1410 BOPD, with a gas-oil ratio of 1050:1, and a formation pressure of 2200 psi.

Hunav. San Juan County, New Mexico, Township 32N, Range 20W. A small subsurface high, productive of oil, gas and water from the Bluff zone at about 5600 feet, with shows of gas in the middle and lower members of the Paradox formation. The structure was drilled to Misissippian strata at 6850 feet. Cretaceous rocks of the Dakota formation are exposed on the surface. The discovery well, Humble's Navajo 1-B, was potentialed in 1956 at 420 BOPD (cut 10 percent water), with a gas-oil ratio of 9773:1 and a formation pressure of 2400 psi. All subsequent development wells have encountered excessive salt water in the producing zone.

Lime Ridge. San Juan County, Utah, Township 40, 41S, Range 19, 20E. A north trending anticline with approximately 500 feet of surface closure. The Rico formation of Permo-Pennsylvanian age forms the surface outcrop. A test was drilled in 1949 to 3214 feet in Devonian strata, and encountered non-inflammable gas in Pennsylvanian strata at about 1800 feet.

Mancos Creek. Montezuma County, Colorado, Township 32N, Range 18W. A small northeast trending anticline with Cretaceous Mancos formation exposed at the surface. A test drilled in 1956 to 6260 feet was bottomed in the top of the Paradox salt. No appreciable shows of oil or gas were encountered.

McElmo. Montezuma County, Colorado, Township 36N, Range 17, 18W. A symmetrical faulted dome with approximately 300 feet of surface closure. The Dakota formation of Cretaceous age is exposed on the surface. A deep test drilled in 1955 encountered granite at 8637 feet. Of the seven test wells, three produce non-inflammable gas from Mississippian strata at about 6500 feet, and one produces inflammable gas from the Shinarump formation of Triassic age.

Monticello. San Juan County, Utah, Township 33S, Range 24E. A small

Continued on Page 75

Delaware Basin—The Next Big Boom?

• Many geologists think West Texas-New Mexico area will yield important oil fields.

• Region already has large gas reserves and many shallow oil pools. Some current drilling aims at deep oil reservoirs.

• Development has been retarded by shooting difficulties and high costs of deep drilling.

• Improvements in exploration methods are needed to promote development of major production.

By C. E. BARNES and E. W. CALDWELL, JR.
Dowell Incorporated
Midland, Texas

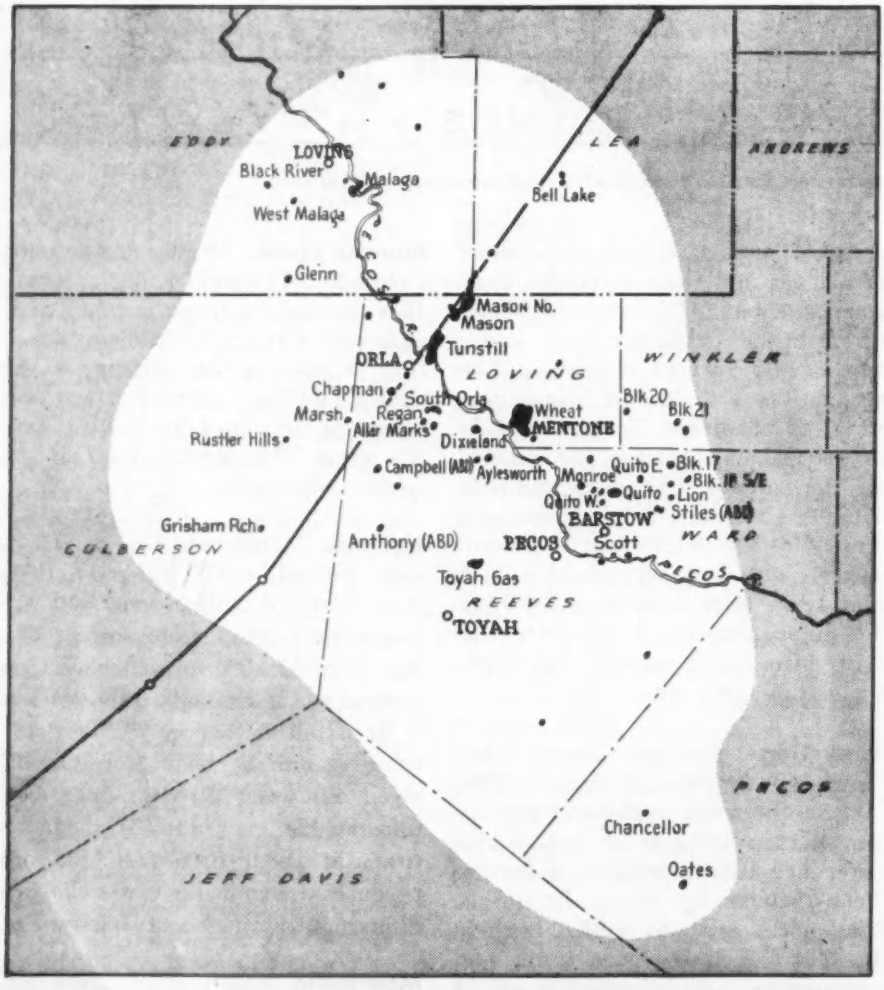


FIGURE 1—This map of the Delaware Basin shows present oil and gas pools. Although only relatively small pools have yet been found, many oil men think that huge stores of oil will some day be discovered within the basin.

THE RELATIVELY undeveloped Delaware Basin may hold one of the nation's biggest oil reservoirs. Although huge stores of gas and many shallow oil pools have been found, no major oil production has yet been discovered. Current deep drilling programs may tap the huge oil deposits that many geologists are convinced must be present in the area.

Geography. The Delaware Basin (Figure 1) extends over about 10,000 square miles in West Texas and southeastern New Mexico. It extends from the Glass Mountains on the south to the Guadalupe Mountains on the north, and from the Delaware Mountains on the west to approximately the eastern boundary of New Mexico. The subsurface eastern border of the Delaware Basin is the Central Basin Platform, which separates it from the Midland Basin.

The Delaware Basin is 100 miles long and 150 miles wide. It is a flat area, with gently rolling hills. Vegetation is sparse because annual rainfall is less than ten inches. Most streams flow only when it rains. The Basin is drained along its entire length by the Pecos River. Except in areas bordering the Pecos, water must be obtained from wells. Most of the Basin is unsuitable for crops or livestock. The ground is covered with sand and fine powdered silt, which forms thick dust clouds during the spring winds.

There are a few good highways through the basin, and gravel roads give access to oil leases. Vehicular travel is limited to surfaced roads. New well sites usually require building service roads. The locations must

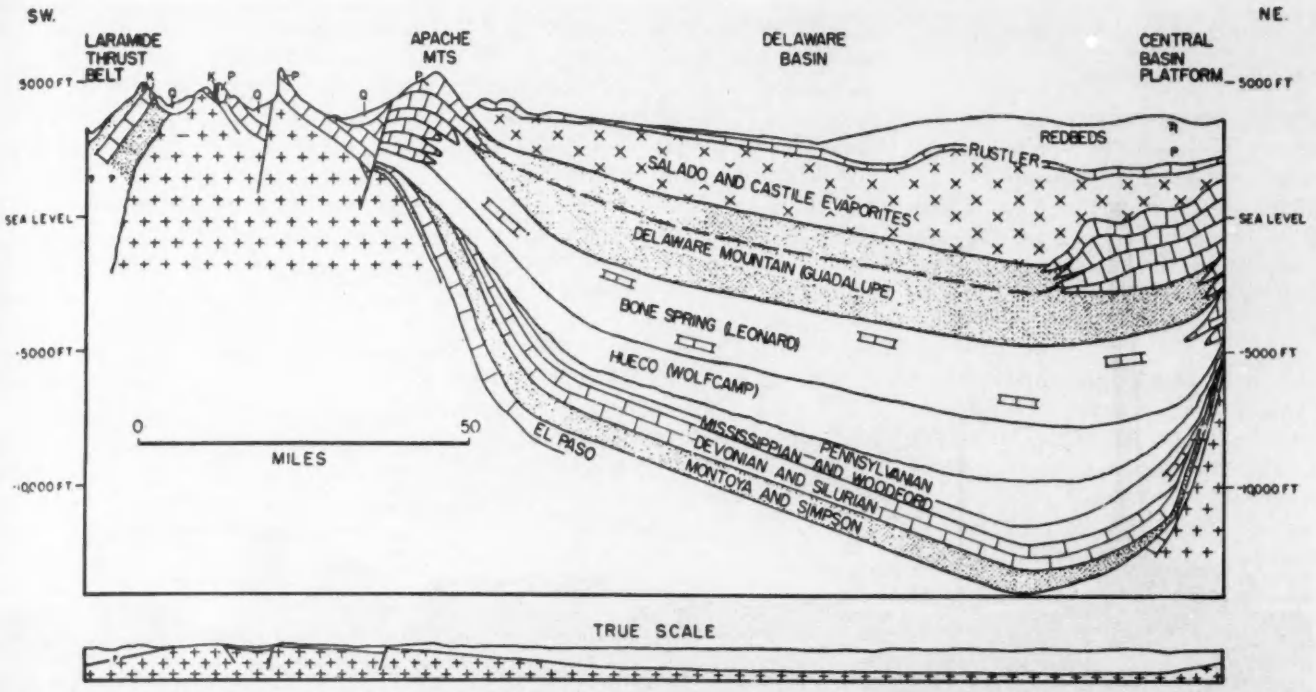


FIGURE 2—This is a structural cross-section of the Trans-Pecos region of West Texas and Southeast New Mexico, along the line shown in Figure 1. Vertical exaggeration is 20.8. (After DeFord, Bull. Amer. Assoc. Petrol. Geol., Vol. 35, No. 2.)

be surfaced in order to handle heavy equipment.

Figure 2 is a stratigraphic cross-section of the Delaware Basin, along the southwest to northeast line shown on Figure 1. The upper portion of Figure 2 is exaggerated 20.8 times vertically. The lower portion of Figure 2 is drawn to true scale.

Geology. An interesting geological feature of the Delaware Basin is the excellent Permian outcrop in the Guadalupe Mountains. This is believed to be the most complete outcrop of Permian rocks in the world. Deposition occurred in the Delaware Basin during each period of geologic time from Cambrian to Cretaceous. Much of the sediment deposited in the Basin came from a land to the east (Lanoria), as it rose and was subsequently eroded.

Both the Delaware Basin and the Midland Basin are contained in the Guadalupe Basin. This area was once an inland sea connected with the Atlantic Ocean by the Mexican trough, which roughly follows the Mexico-U. S. border to what is now the Gulf of Mexico.

Toward the close of the Paleozoic era there were world-wide mountain-building disturbances. These disturbances are referred to in this area as the Marathon orogeny. As the Pennsylvanian period ended and the Permian period began, the Guadalupe Basin started to sink gradually and deposition started on Wolfcamp series.

The Wolfcamp series consists of marine deposits that rest unconformably on the Marathon folds of Pennsylvanian age. Most of the Wolfcamp is limestone and shale, interbedded throughout the Basin to a thickness of five to seven hundred feet. In the Glass Mountains the Wolfcamp outcrops, then dips eastward under younger rocks to reappear in North Central Texas, largely as shale beds with some limestone formations.

The Leonard series is more than two thousand feet thick, and is similar to the Wolfcamp series. The rocks run more to thick shale beds interbedded with limestone, and remain wholly marine. Near the top of the Leonard series the beds gradually grade into calcium sulfate, indicating severe aridity and extensive evaporation over the Guadalupe Basin. The Delaware Basin was formed about the time the last of the Leonard series was deposited. The Delaware Basin and the Midland Basin then started to sink within the Guadalupe Basin.

The Guadalupe series, which is most fully developed in the Delaware Basin, began with a large reef structure that formed around the margins of the Delaware Basin. This reef, called the El Capitan, stands out in bold relief with cliffs some 1300 feet high, just south of Carlsbad, N. M.

Outside of the Delaware Basin, the Trans-Pecos region was an arid lowland where evaporation deposited salt, gypsum, and anhydrites from waters trapped between the higher ground and the reef structure surrounding the basin. Interbedded with these salt beds are red beds formed from sediment deposited by water flowing into the area from higher lands.

Delaware Mountain Sands. In the depths of the basin, dark shales, limestones and silt-stones were deposited. The Delaware Mountain group of sands were deposited at this time, interbedded with dark shales.

The Capitan limestone appears to over-lie the Delaware mountain group in some areas. This is because of the intertongue overlaps between the reef structure and the sand formations. Near the end of Guadalupe series deposition, the climate grew increasingly arid, and the surrounding lands became vast desert lowlands.

The Ochoa series, last of the Permian section, consists entirely of depositions from a dead sea. Evaporation formed thick salt and anhydrite ($CaSO_4$) beds about 4450 feet thick, which finally filled the Delaware Basin. These salt beds, known as the Castile, Salado, and Rustler formations, were deposited in that order. The Dewey Lake redbeds of non-marine origin were deposited to close the Permian period.

Deposition during the Triassic and Jurassic periods was light, forming thin beds of brightly colored rocks.

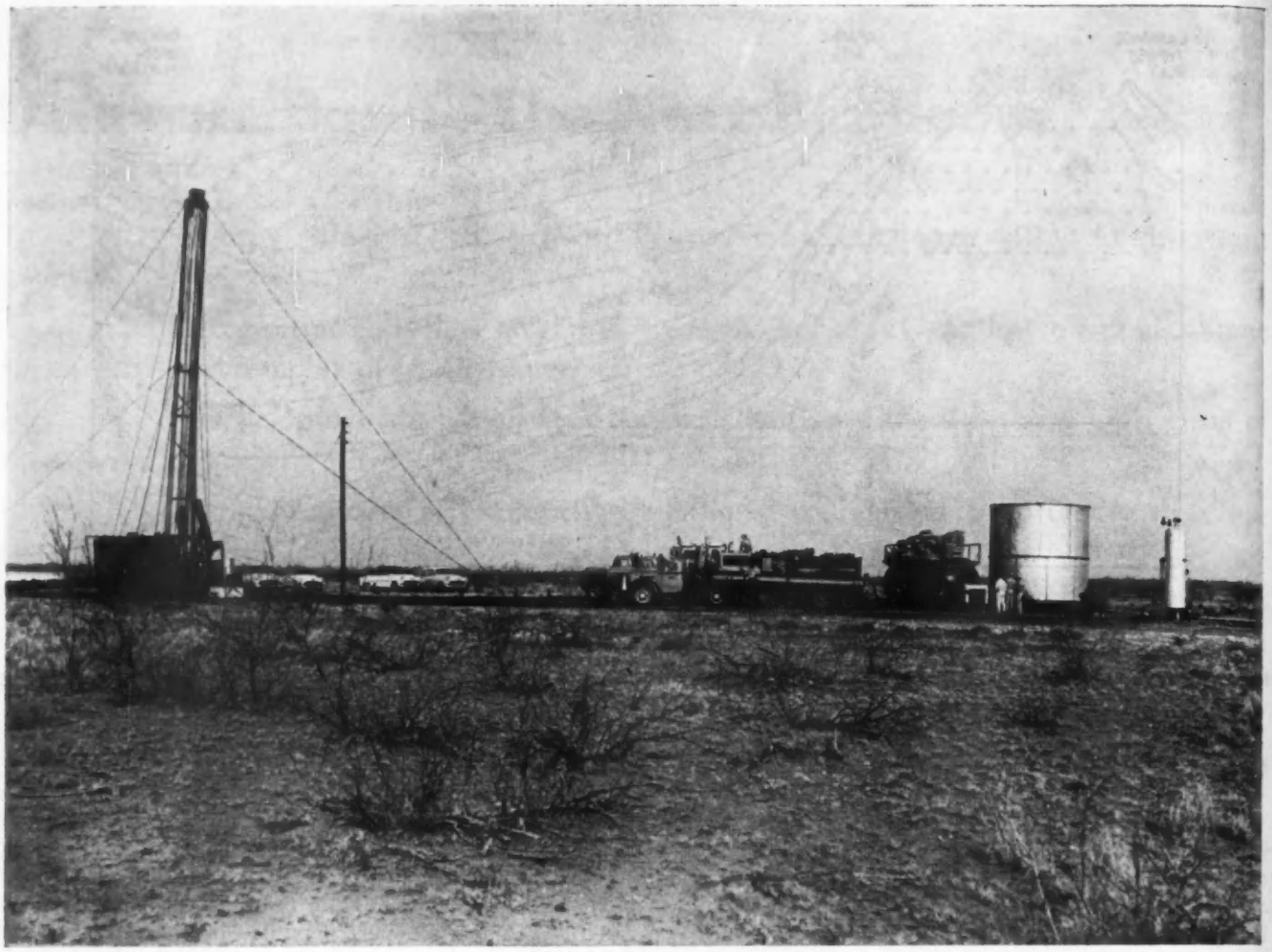


FIGURE 3—The Delaware Basin holds great promise for future oil and gas production. Further exploitation and development may turn the Basin into a major "hot spot."

One of these beds is the Dockum group, of Triassic age, found up to two hundred feet thick in the Yates pool of the Central Basin platform. It is hard to distinguish between Permian rocks and those of early Triassic age. In some areas, the ages of these beds are highly controversial.

The Cretaceous period ended deposition in the basin with beds of fine sand occurring throughout the area. During Cretaceous time, extensive volcanic activity occurred over the Mid-Continent area, and some volcanic ash may be found scattered throughout West Texas.

Production. Oil has been found in small quantities around the edges of the Delaware Basin. This production is from shallow wells, with the best ones making about 80 barrels of oil per day. Considerable gas also has been found in deep test wells throughout the Basin.

Most present oil production comes from the Delaware Mountain sands of Permian age. High-volume gas production comes from the Permian age Wolfcamp formation at depths up to 16,000 feet. High gas potentials in the deep test wells have drawn more and more companies into the basin with intensive drilling programs.

Drilling in the Delaware Basin is both costly and extremely hazardous. High gas pressures encountered while drilling present a constant threat. Numerous wells have experienced blowouts, and several disastrous fires have occurred.

In spite of these difficulties, several fine gas producers have been drilled. Continental's Bell Lake unit 1-A, completed from 14,942-15,025 feet, produced 15 million cubic feet of gas per day. The El Paso Natural Gas Company's Welch 1-X was completed at 12,502-22 feet for 27 million cubic feet per day. Both of these wells were in the northern part of the basin.

Shell Oil Company recently drilled a deep test at the eastern edge of the Delaware Basin near Wink, Texas, in Winkler County. The test went to 17,410 feet in the Devonian. In successive plug-backs, several shows were found, but no commercial production resulted. At last report, the well had been plugged back to 5000 feet and was being tested.

Other deep Wolfcamp tries on the western and southeastern edges of the Delaware Basin have not been successful, although several tests have looked promising. Such wells declined rapidly, becoming non-commercial.

The record holder for depth in the Delaware Basin is a well drilled in 1953, which reached 16,705 feet, and was still in the Wolfcamp formation. The well flowed 1527 cubic feet of gas and four barrels of distillate per hour, from a depth of 12,343 feet, producing from a 15-foot section of Permian sand. These deep well tests, although promising, have given no clue to where suspected large deposits may lie.

Handicaps. Drilling in the Delaware Basin is limited for several reasons. One is that no present exploration

method tells the best possible places to drill. A second reason is the prohibitive cost of drilling such deep wells.

Several factors hamper exploration. Surface mapping is difficult because of the nature of surface deposits and the thick layers of blow sand on the surface. Reflection seismographing has not been as effective here as in most other areas, because of the loss of energy near the surface and through the thick salt sections.

Drilling hazards and shooting difficulties have thus far retarded exploitation of the Delaware Basin. Oil producers have been forced to rely on wildcat drilling. This method is expensive and slow. Wildcat wells may often miss highly productive anomalies by short distances. The cost of drilling a 14,000 or 15,000 foot test hole is so great that wells must be widely spaced in order to cover a large area. Apparently, development of major production in the Delaware Basin depends on improving exploration methods and equipment, or drilling many more test wells in order to obtain more detailed stratigraphic correlation.

Over 50 Pools. The Delaware Basin contains more than 50 oil and gas pools, differing in size and importance. These pools have many characteristics in common. Most wells are initially completed with good bottomhole pressure and good potentials, running from 125 to 250 barrels per day. Usually, wells decline rapidly, dropping as low as 5 to 10 bpd within 5 or 6 years. Although many of the wells are natural completions, formation fracturing treatments are commonly employed to stimulate depleted production. Such treatments average from 2000 to 3000 gallons of oil, with sand concentrations ranging from 1 to 2 pounds per gallon. The average injection rate is about 7 barrels per minute.

Some of the major Delaware Basin pools are the Quito, Wheat, Tunstill, Mason, North Mason, and Toyah. The Quito was discovered in 1953. The first well potentialed 42 bopd, flowing from 4984-5005 feet. There are five production zones in this pool, ranging from 4800 to 5050 feet. Most Quito wells produce from 80 to 120 bopd on completion and decline within 12 to 18 months to about 25 bpd.

The Wheat pool was discovered in 1926. Its peak production years were 1931 and 1932, when 1¼ million bbls of oil were produced. The average well depth is 4300-4400 feet. Drilling continued in this pool until about two years ago. Large fracturing jobs have been common here. Treatments of from 10,000 to 20,000 gallons of fluid, injected at rates up to 20 bpm, have resulted in worthwhile production increases. However, these wells usually decline rapidly, following stimulation treatments. Several wells have been given fracturing treatments, using 50,000 gallons of water and 30,000 pounds of sand, which increased production considerably.

Tunstill Pool. In 1947, the Tunstill pool was discovered in the upper Delaware sand, from 3200 to 3400 feet. Some of these wells were initially completed with potentials as high as 400 bopd. Production in most of them, however, ranged from 150 to 200 bopd. In 1952 and 1953, many small fracturing treatments increased production as much as 120 bopd. These increases declined gradually over a period of 9 to 18 months. Large fracturing treatments almost invariably opened water zones.

The Mason pool was discovered in 1937, with production from 3890 to 3950 feet. The North Mason, discovered in 1952, produces from 4045 to 4100 feet. Later discoveries between these two pools have shown that they may be a single pool. These wells follow, in general, the pattern of other pools previously discussed, with good initial production followed by rapid declines. Large fracturing treatments have been performed here, as in the Wheat pool, without fracturing into water zones.

Newer discoveries have been the Regan, South Orla and Allar-Marks pools. These pools are close together, and it is possible that future wells may show that these pools are connected. Wells here are completed for 125 to 175 bpd, with production declining within 18 months to about 20 bopd. Fracturing has not been an effective stimulation method in these pools.

The Toyah gas field produces from the Devonian at 12,600 to 12,700 feet. Although the wells have shown excellent potentials, activity is presumably shut down because pipe line facilities are not available.—**The End**

Structures of Paradox Basin

Continued from Page 67

domelike structure with approximately 50 feet of closure at the surface. Cretaceous rocks of the Dakota formation form the surface outcrop. The structure has been tested to the Paradox salt at 5831 feet with shows of oil and gas reported in the upper member.

North Chimney Rock. San Juan County, New Mexico, Township 32N, Range 17, 18W. A small northeast trending anticline with the Mancos formation of Cretaceous age exposed at the surface. The discovery well, Southern Union's Navajo 1-A, was drilled in 1953 to 8150 feet in Mississippian strata. It was potentialed at 14 MMCFPD inflammable gas from the lower member of the Paradox formation at about 7600 feet, with a formation pressure of 3400 psi.

Point Lookout. Montezuma County, Colorado, Township 35, 36N, Range 14W. A small northwest trending anticline with the Mancos formation outcropping at the surface. The structure was drilled to Devonian strata in 1956 to 8130 feet. Shows of gas were encountered in the Dakota formation at 200 feet.

Raplee. San Juan County, Utah, Township 41, 42S, Range 19E. A large north trending anticline with a surface closure in excess of 500 feet. Permian and Pennsylvanian strata are exposed where the San Juan river breaches the anticline. The structure has been tested to Pre-Cambrian rocks at 1870 feet. Shows of gas were reported in Pennsylvanian and Mississippian strata.

Ute. San Juan County, New Mexico, Township 32N, Range 14W. A small faulted dome with approximately 200 feet of surface closure. It adjoins and lies slightly southeast of Barker Dome. Production and reservoir characteristics are the same as those of Barker Dome.

Several structures and new discoveries shown in Figure 1 were obviously omitted in the discussion of structures. Little or no information was available on these structures.

ACKNOWLEDGMENT

The author wishes to express appreciation to El Paso Natural Gas Company for permission to write the article, and to recognize previous publications in the area by various authors.

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Organization, Planning Speed Rig Move

Pre-planning, unitization of equipment, flexibility of diesel electric drive combine to speed rig move for deep West Texas test.

By **JOHN N. SCHUELKE**
World Oil Staff

Transportation and rig-up—cost items that are looming ever larger on the contractor's books—are factors that deserve more and more consideration and planning in today's drilling industry. How the proper planning and organization of a rig transport and rig-up cut at least three days from normal rig-up time was demonstrated recently by the Great Western Drilling Company when moving its new diesel-electric rig onto a deep wildcat location for Phillips Petroleum Company in Pecos County.

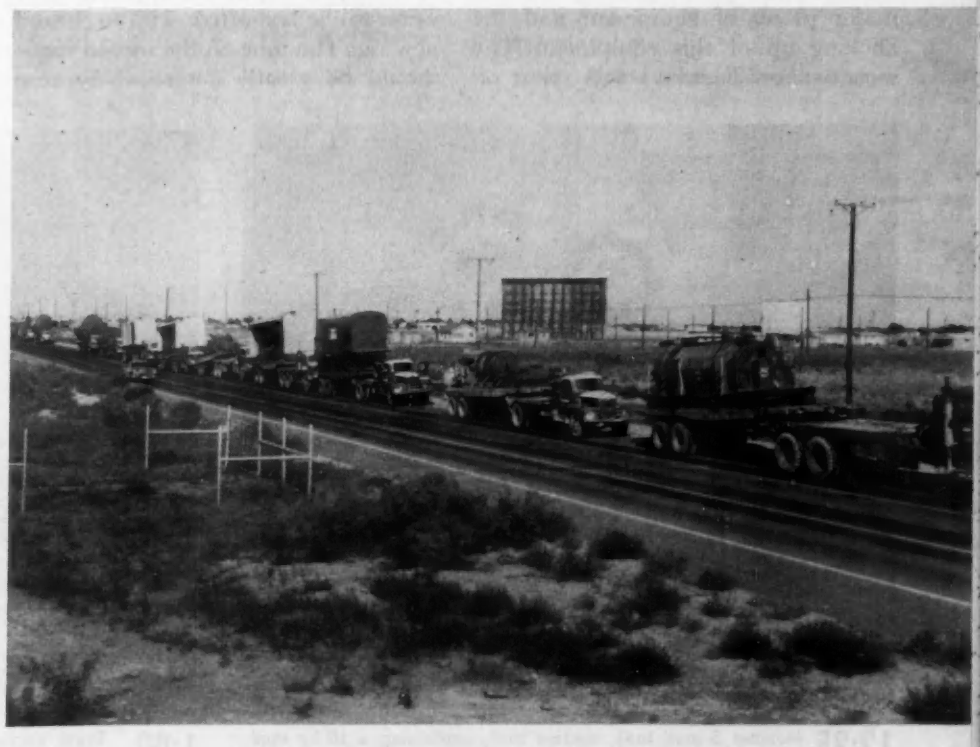
The new rig, capable of drilling to 22,000 feet was assembled at Great Western's yard in Odessa, Texas. Here the major components were fitted together and tested and then rigged-down for the 125 mile move to the location southeast of Fort Stockton, Texas. This move demonstrated what advance planning could do in saving manhours and avoiding confusion at the rig site. It is a credit to the men who planned this move that as each truck arrived on location, it was able to spot its load almost immediately, and then leave the location. It was not necessary for any of the loads to be dropped off at the location and then picked up later. The only re-handling of the equipment was from floats or pipe trailers to flatbed trucks for spotting.

Prior to the actual move of the drilling equipment, the location had been prepared and cement piers and flooring installed. The cement piers were 5 feet, 8 inches high and had a 10-square-foot base and 3½-square-foot top. Ninety cubic yards of cement was used in pouring these piers. An additional 26 cubic yards of cement was used on the 6-inch thick flooring. Cement runners were also provided under the drawworks substructure.

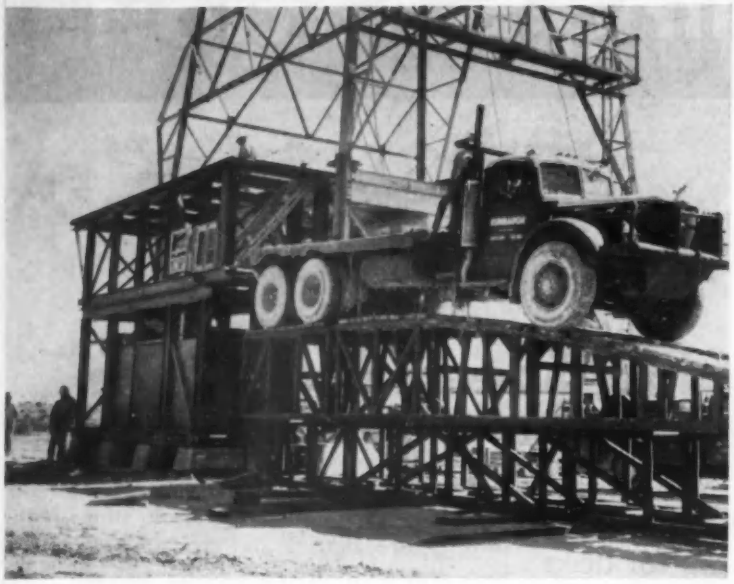
Besides the site preparation, the substructure, derrick and crown block were erected in advance of the move. The walkway, pipe slide and pipe racks had been moved onto location and positioned, and an advance load had delivered the blocks, swivel, bails and spool of 1⅜-inch wire lines.

On the day before the actual move, the drawworks substructure had been sent to the location but it was not positioned until the morning of the actual move.

Promptly at 5 a.m. on a Monday morning, the first four trucks with drilling equipment left Great Western's yard in Odessa. These trucks carried two 500-barrel water tanks and the two sections of the 1200-horsepower drawworks. The contract



Truck convoy as it was loaded out preparatory to leaving Odessa, Texas, for rig site 125 miles away. This was not the order in which the trucks were moved onto location.



10:30 Upper half of drawworks substructure is skidded into place. Note the sample and mud testing doghouse in lower half of substructure. A workbench and tool bin are built in on other side.

11:15 The number 3 mud tank 50 feet long is lowered into position. This mud system employs five tanks, three, 50 feet long and two, 30 feet long with a total capacity of 1225 barrels.

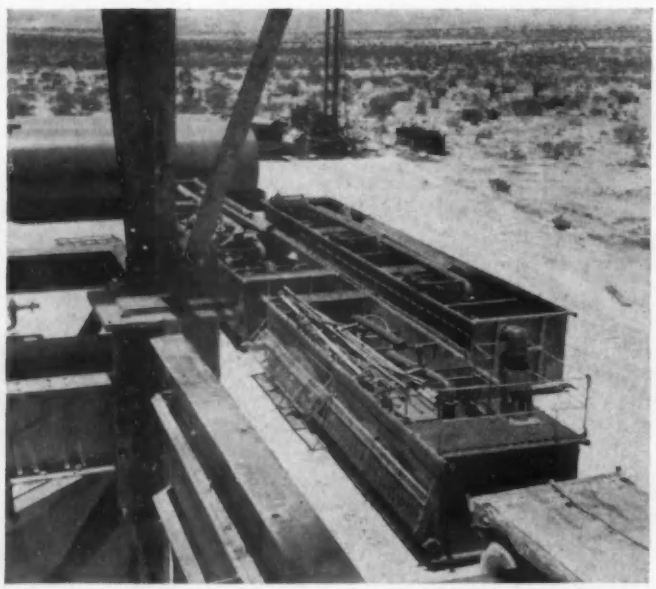
specified that 2500 barrel capacity be provided for water storage.

At approximately 8 a.m. the remainder of the convoy was to start leaving the Odessa yard at specified intervals in the order in which they were to arrive at location, so that their loads could be spotted as they arrived. The specified intervals were used so that there would be no jamming up of trucks and equipment at the location.

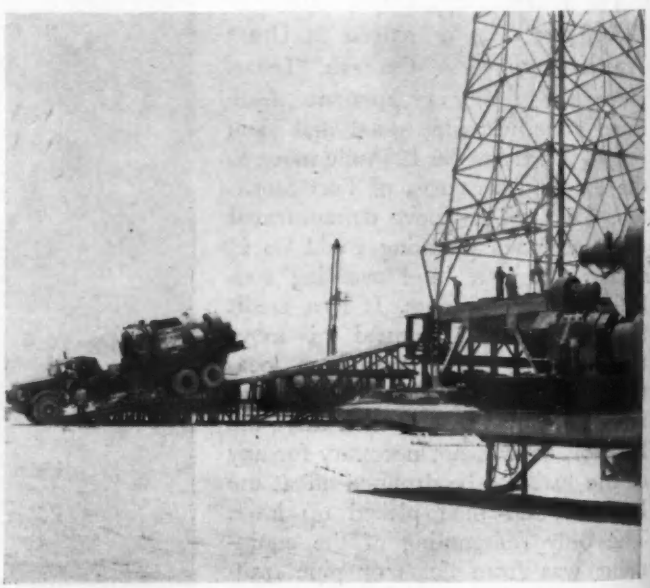
The first day (Monday) was used almost entirely in spotting of the major pieces of equipment and the hooking up of this equipment. The second day (Tuesday) was spent on the maze of small rig-up chores that accompany any rig move. These chores are especially prevalent around a new rig where various fixtures and small equipment had not been attached to the rig previously. Holes had to be drilled or burned with a cutting torch to install the dead man and air hoist, a new set of rig lights had to be made up and installed, and electric cables had to be strung, connected and parts of it entrenched. These new installations hindered the crews in a rapid rig-up, but they were to be expected with a brand new rig. The time on the second move should be greatly decreased because this fabricating and installation work is now in the past.

From the start of the move on Monday morning until the rat hole was spudded in at approximately 4 p.m. Wednesday only 2¼ days had elapsed. Because of the very difficult drilling in the boulder-like formation immediately below the surface, difficulty was experienced in setting the rat hole pipe and it was not until approximately 9 a.m. Thursday that the well was actually spudded. This represented only slightly more than three days for a 125-mile move and rig-up.

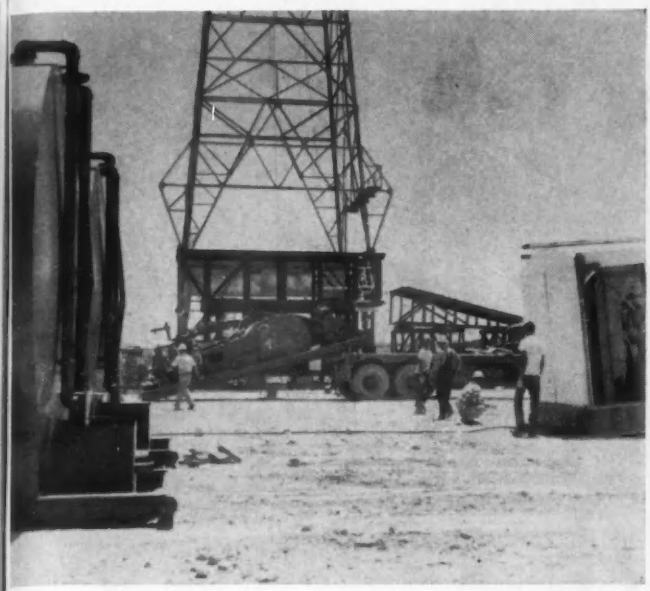
The pictures on these pages show



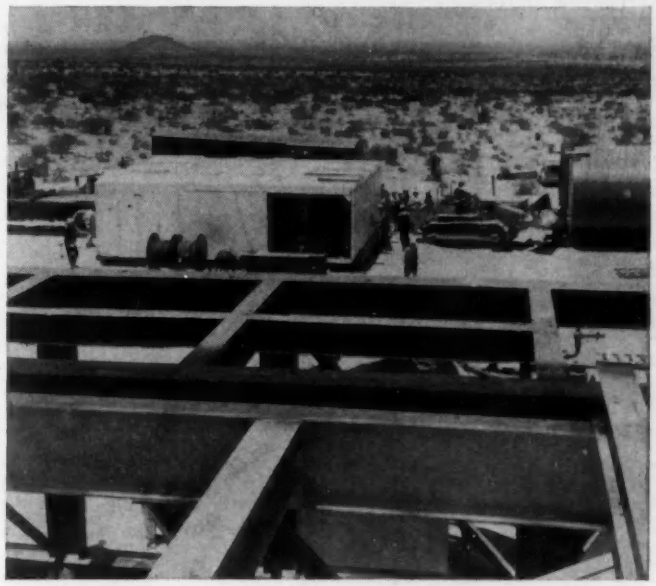
12:35 Number 5 mud tank, suction tank, containing a 10 hp mud mixer has just been spotted. Crews are already at work connecting up number 3 and 4 tanks. Tank was spotted at 12:10.



1:00 Drum section of the drawworks with the electric particle brake and drilling control starts up the ramp. This part of the drawworks was in position at 1:20.



11:20 Pre-planning is apparent as one of the 700-hp mud pumps and one of the power shed sections, containing two turbo-charged diesel engines driving a 500-kw generator, are spotted.



12:30 Third section of the power shed has been spotted. Three sections fit together to form one complete engine shed housing over 2000 hp. The second section had been spotted at 12:10.

how more than two or three pieces of equipment were being spotted at the same time. This reflects the pre-planning in the layout of the location. The ease and flexibility of rigging up a diesel electric rig is demonstrated by the lack of alignment problems between the motors, compounds, pumps, etc. With a 30-foot high substructure being used on this well the lack of an engine substructure greatly reduced the loads and the weight that had to be transported.

With a probable depth in excess of 22,000 feet this contractor is faced with a long stay in one location. This is the reason behind the cement foundation and the use of first class equipment. Tentative drilling practices have been set out and these include the tentative hole and casing program as shown in Table 1. The probable size of drill collars and drill pipe in the various sized holes is given in Table 2.

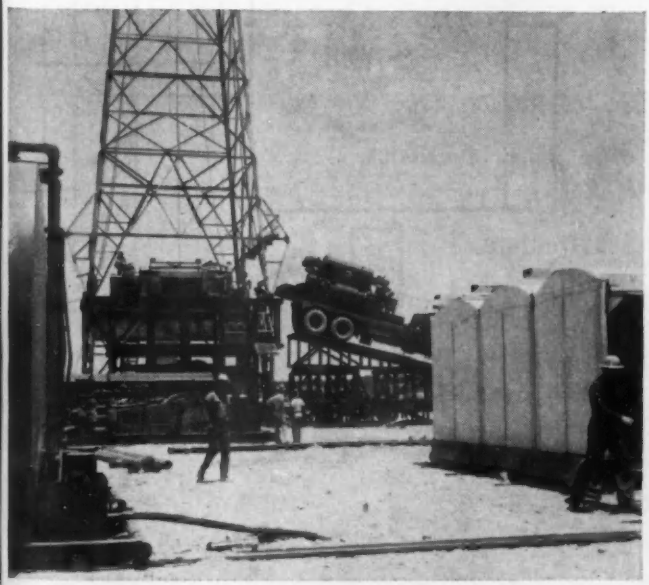
TABLE 1

Proposed Hole and Casing Program

Drilling Interval (Feet)		Hole Size (In.)	Casing Length and Size
From	To		
0...	1,800	24	1,800 ft. of 20-inch
1,800...	15,000	12¼	15,000 ft. of 9⅝-inch
15,000...	T.D.	8½	Liner of 7-inch

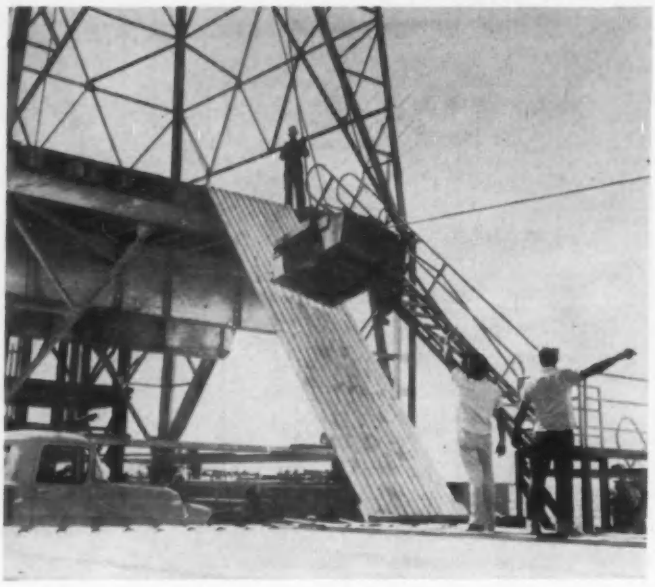
Here is a large rig that is capable of drilling the deepest well in the world that set an amazing pace for transporting and rigging up. A move such as this shows what can be accomplished with proper planning of all of the details that go into a rig move. Certainly a move that was as well organized as this effected a great savings in time and money and represents a real accomplishment in the drilling industry.

Picture story continued next page

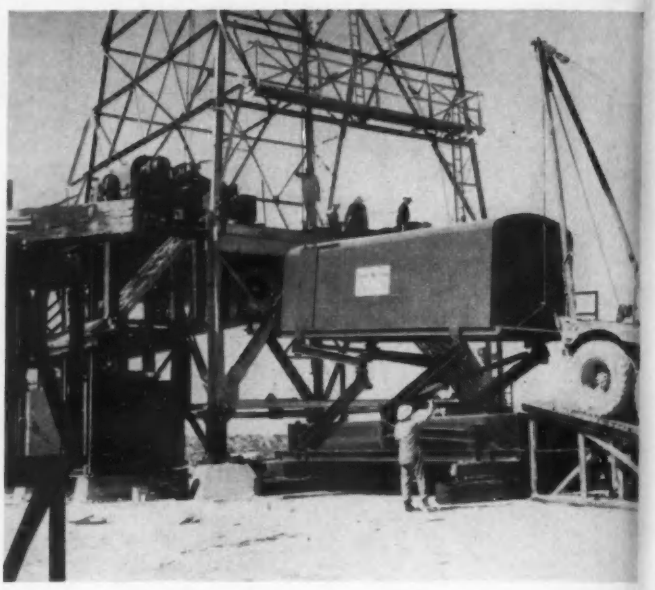


1:40 Drawworks transmission with the two 600-hp electric motors in place is winched onto substructure. Note second mud pump spotted at 12:10 and mud house at 12:15.

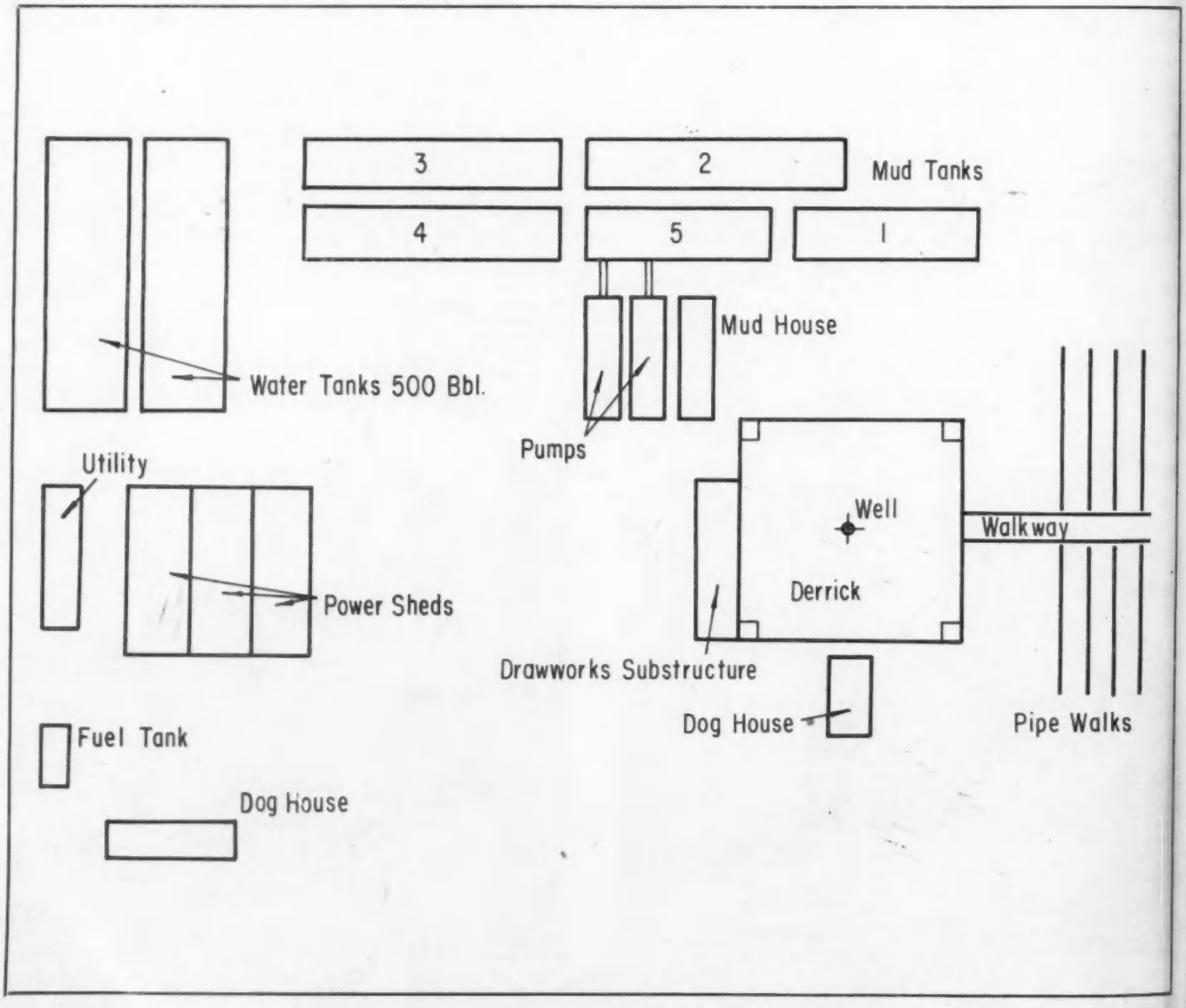
2:10 The number 1 and number 2 mud tanks are spotted simultaneously. Due to pre-planning and site layout simultaneous spotting of equipment could be carried on without interference.



3:30 The 27½-inch rotary table is hoisted onto the rig floor. This is one of the largest rotaries ever built. Due to a well organized move, most of the large equipment is now in position.

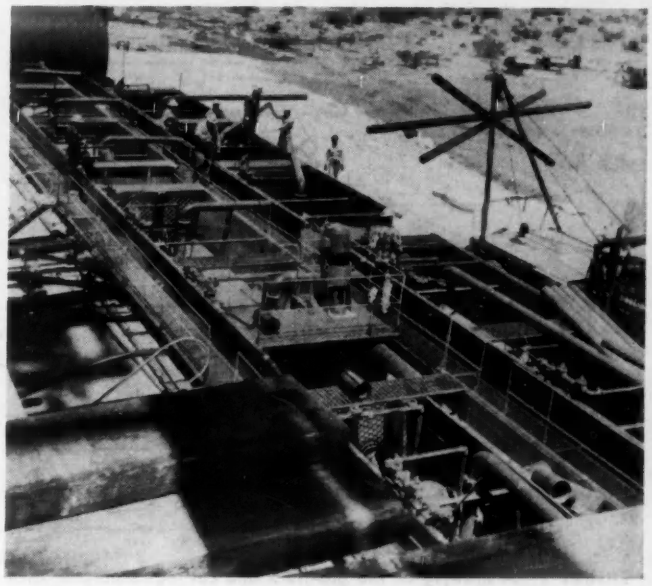


4:15 The doghouse and change house are spotted and being raised into position. These collapsible legs made it possible to transport the junk bin, doghouse and supports all in one load.

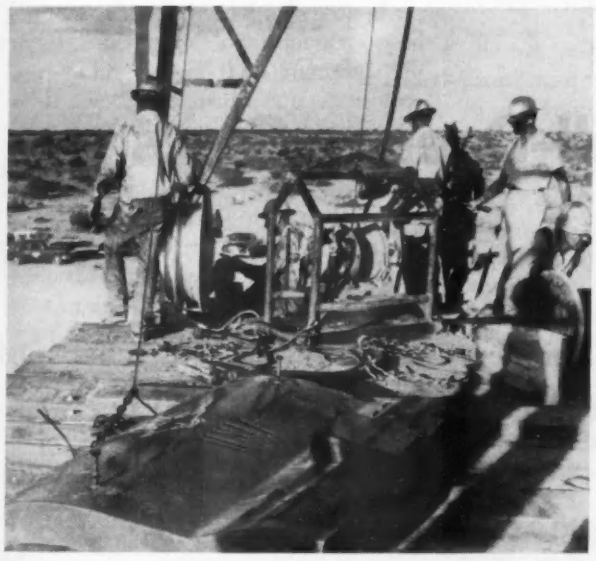


A schematic drawing showing drillsite with equipment layout.

4:20 Crewmen start stringing conductor cables to motors and controls. All electric cables for rig were wound on two spools, skid-mounted and positioned near the main control panel.



4:30 As jet line extensions are being added, the main mud pumps and mud tanks are practically hooked up. Walkways, guard rails, mud guns and jet lines only had to be fastened in position.



SECOND DAY

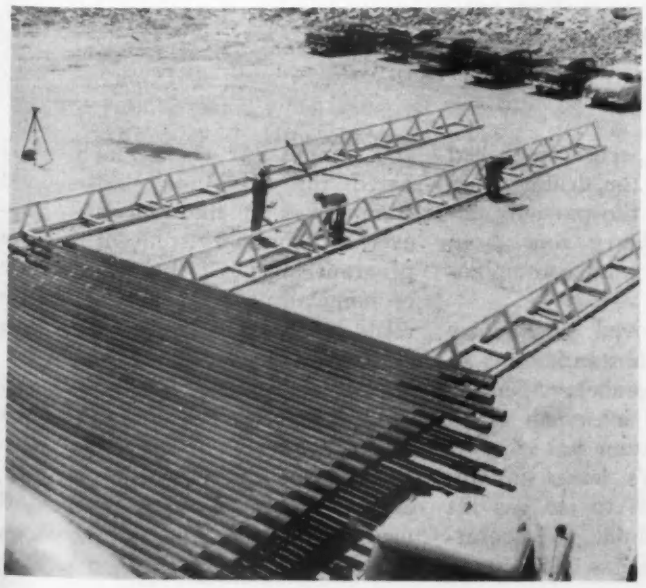
(Left) The installation for the first time of small pieces of equipment such as the dead man anchor and the air hoist hindered rigging operations to a certain extent. Here it was necessary to bore through the wood floor and anchor both of these pieces to the metal substructure.

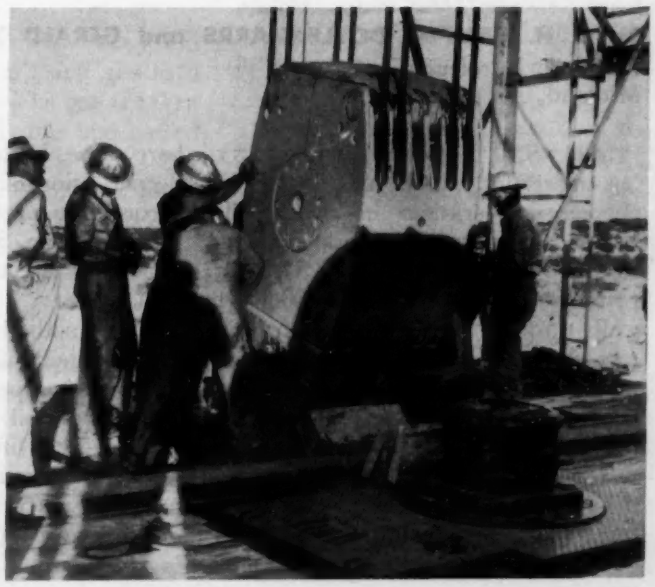
4:00 (Second Day) Pipe rack (lower left) is extended and some of the 5½-inch drill pipe that will be used on this well has already been racked. The third rack is placed to handle the range 3 casing that will be used.

TABLE 2
Drill String Make-Up

Hole Size (Inches)	Drill Collar Make-Up	Drill Pipe
24.....	3—11¼ inch O.D. 6— 9¾ inch O.D. 10— 8 inch O.D.	5½-inch O.D.
12¼.....	Same as above	9,500 ft. of 5½-inch Balance 4½-inch
8½.....	20—6½ inch O.D.	Same as for 12¼-inch hole

7:30 (Second Day) Blocks are strung and hoisted from the rig floor. At this stage most of the small chores of rigging up had been completed. Standpipe, monkey board and flow line still had to be installed and the rat hole was started at 4 p.m. on Wednesday the third day.





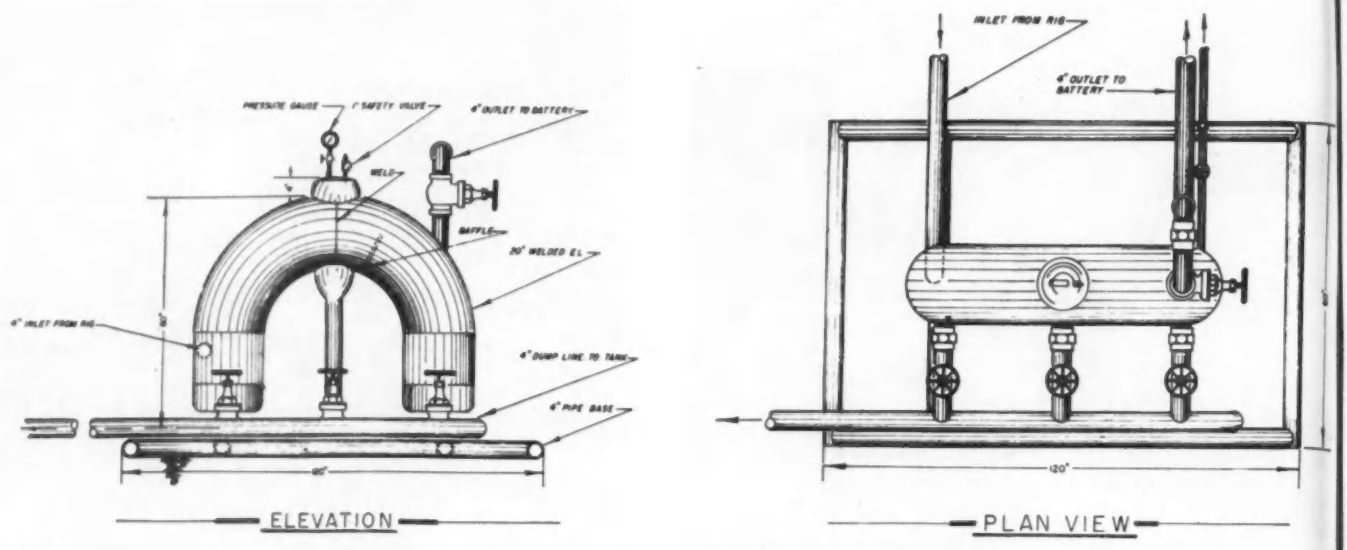


FIGURE 1—A drawing of the gas-fluid and cuttings separator used for the drill deeper operations. Return fluid from the well entered the separator where the cuttings fall out and the remainder of the fluid stream hits the baffle plate. The oil is carried over the baffle plate and is collected in the trap opposite the inlet. Fluid and cuttings are blown out periodically.

Gas Drilling Reduces Drill-Deeper Costs

Deepening operations to the Lower Spraberry using gas lift gas, chert and diamond bits, and reselling returned gas have reduced drilling costs $2000 per well.

By C. H. SAMPLE, DOYLE MARRS and GERALD YOUNG
Magnolia Petroleum Company
Midland, Texas

MAGNOLIA PETROLEUM COMPANY has successfully used natural gas in deepening operations in eight wells in the Spraberry Trend area field, Midland County, Texas. Drilling costs have been reduced $2000 per well through increased penetration rate, reduced rig time, and a unique method of separating gas and cuttings which allows the sale of the return gas.

The drill-deeper operation involved drilling 700 feet of additional hole from the upper Spraberry zone at a depth of 7200 feet to the lower Spraberry zone. Initially, wells were drilled deeper using oil as the drilling fluid in order to protect the partially depleted upper Spraberry zone from damaging effects of mud contamination.

This method proved satisfactory but resulted in a substantial loss of oil to the upper Spraberry. Due to this loss of oil and inasmuch as an extensive gas lift system was in operation on Magnolia's leases in this area, it was decided to try gas lift gas as the drilling fluid. The operating pressure of the gas lift system, 700 pounds per square inch, eliminated the need for skid-mounted compressors at the well site. However, a preliminary study of this type program indicated that it would be economically feasible only if the gas could be separated from the cuttings and returned for sale.

This led to the design of a gas-fluid and cuttings separator which is illustrated by Figure 1. This apparatus was designed so the gas, fluid, and cuttings blown from the well would enter the separator as shown by Figure 1 and be given a swirling

action to reduce erosion on the internal surface. The majority of the cuttings fall from the gas stream at the inlet to the separator. The remainder of the cuttings strike the baffle at the top of the separator and fall into the center cuttings trap. The oil that is produced from the upper Spraberry zone is carried over the baffle and is collected in the bottom of the trap farthest from the separator inlet.

Periodically, the fluid and cuttings are blown from the separator traps by manually operating the gate valves to the four inch dump line. This dump line is connected to a blow down tank in which the oil can be salvaged. Figure 2 shows the location of the gas line, separator, and blow down tank with respect to the rig. The gas is taken off the top of the separator and returned to the production separator at the tank battery through the oil flow line which is not in use during the drill-deeper operation. The gas is then metered and sold to the transmission company. Therefore, the only cost for the gas is the standard compression charge and the cost for the small volume of gas used in blowing the cuttings and fluid from the gas-fluid and cutting separator. The latter cost can be kept at a minimum if only that volume of gas necessary to remove the fluid and cuttings from the separator is used. This can usually be established by trial and error.

Actual operations in eight wells have shown that an additional saving is realized through increased penetration rates resulting in reduced rig time.

The first well was drilled deeper using conventional rock bits. The penetration rate was increased approximately 240 percent over the average rate obtained when using oil as the drilling fluid. However, conventional rock bits had the following disadvantages:

1. Extra rig time is consumed in tripping for new bits.

2. An excess volume of gas is lost in blowing down the hole for trips.

The entire footage in the second well was drilled using one diamond bit and this same bit was used in two subsequent wells. The diamond bit eliminated the rig time involved for trips but the penetration rate was increased only 170 percent over the rate obtained using oil. Nonetheless, the over-all rig time was still reduced from approximately 170 hours to 140 hours. In order to attempt to improve the penetration rate obtained when using the diamond bit, it was decided to try a carbide insert chert bit. This bit made the entire footage without tripping and offered the following advantages over the diamond and conventional rock bits:

1. The penetration rate was slightly greater than the rate obtained with the conventional rock bit.

2. The rig time was reduced considerably.

Table 1 compares drilling with a diamond bit using oil as the drilling fluid and drilling with a rock bit, diamond bit, and chert bit using gas as the drilling fluid.

Very little trouble has been encountered to date in using gas as a circulating medium. The gas is taken from a gas lift supply line and passed through the drill pipe at 500 to 650 pounds per square inch gage pressure and a rate ranging from 1000 to 2000 cubic feet per minute. There has been some trouble with the drill pipe tending to stick when the dry cuttings from the bottom of the hole come in contact with the fluid productive formation above and "gum up" around the drill pipe. Then it is necessary to inject from three to five barrels of oil through the drill pipe to lubricate the cuttings and circulate for approximately 20 to 30 minutes.

After the hole has been drilled to the liner seat, the liner is cemented in the conventional manner; however, it is necessary to first fill the hole with oil. No difficulty has been encountered in cementing liners in the gas drilled holes.

As a result of these field trials, Magnolia has found that a saving of approximately $2000 per well can be realized using gas as a drilling fluid instead of oil.

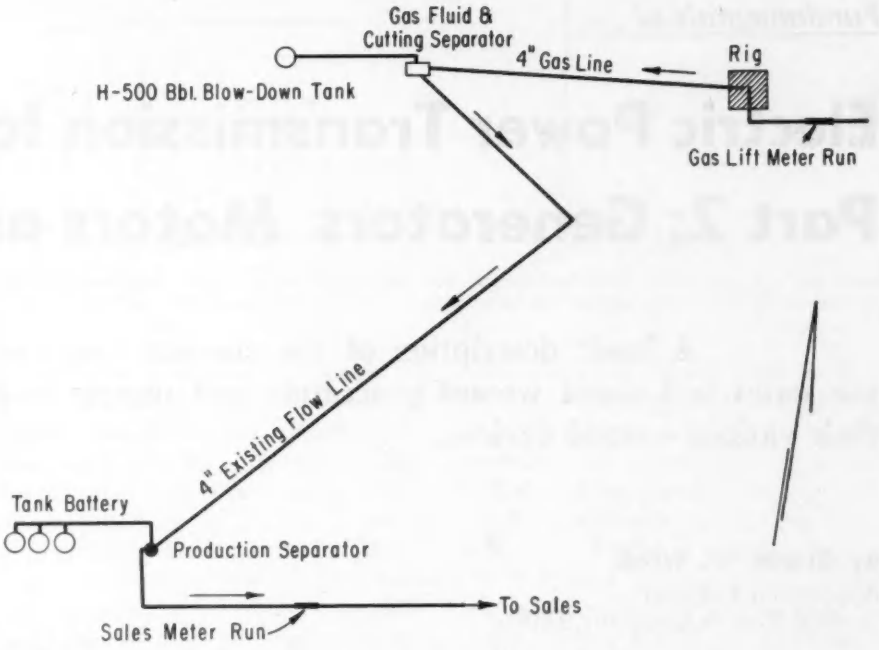


FIGURE 2—A plat of the area showing the location of the rig to the separator and the gas lines.

ACKNOWLEDGMENT

The authors express their appreciation to Magnolia Petroleum Company for granting permission to print this article and to B. S. Welton, field petroleum engineer in the Spraberry Trend Area field, for assembling the data used in the article. Prepared by: C. H. Samples, district production superintendent; G. S. Young, assistant district production superintendent, and Doyle G. Marrs, district petroleum engineer.

TABLE 1
Comparison of Drilling Operations (Oil vs. Gas)

Type of Drilling Fluid	Oil	Gas	Gas	Gas
Type of Bit	Diamond	Rock	Diamond	Chert
Total Rig Time to Liner Seat, Hours	190	172	140	90
Trip Time, Hours	11	60	13	5
Rotating Hours	151	59	75	57
Penetration Rate, Feet/Hour	4.7	11.4	8.0	11.1
Weight on Bit, Lbs.	6—10,000	8—10,000	8—10,000	8—10,000
Rotary Table, RPM	70–80	60–70	60–70	60–70
Diameter of Hole	4⅝"	4⅝"	4⅝"	4⅝"

Fundamentals of . . .

Electric Power Transmission for Drilling Rigs Part 2: Generators, Motors and Controls

A basic description of the characteristics of the series and shunt wound generators and motors and their various control devices.

By GLENN W. WEBB
Application Engineer
General Electric Company, Dallas

THE OPERATION OF any DC electric motor or generator can be understood and the performance predicted under various conditions by understanding two simple basic relationships. Any motor is based on the principle that when a conductor (copper wire) carrying an electric current is placed in a magnetic field such as between the poles of a horseshoe magnet, a force will be exerted on the conductor tending to move it in a certain direction. This force will be proportional to the amount of current flowing in the conductor and proportional to the strength of the magnet. If we arrange the conductor or wire in a loop or coil pivoted between the poles of a horseshoe magnet we will have a simple DC motor. If we connect a battery across the two ends of the coil to cause current to flow through the wires in a certain way, the coil will rotate. The principle stated above says that the force or torque causing the coil to rotate could be doubled by using two magnets or by doubling the amount of current from the battery. Our first basic relationship is that the torque exerted by a motor is directly proportional to its current (amperes) and to the strength of its magnetic field.

$$\text{Motor Torque} \cong \text{Current} \times \text{Field Strength} \quad (3)$$

The stationary part of a modern DC motor consists of strong electromagnets arranged to produce a very concentrated magnetic field. The rotating portion of the motor contains copper wires or bars to carry the current which is conducted to them through carbon brushes riding on a cylinder or copper segments to which the wires are attached. When the electromagnets are energized and current is supplied to the "rotor" forces are exerted on the individual conductors all in the same rotational direction to cause the rotor to rotate in its bearings and produce torque at the shaft.

We can restate Relationship 3 by putting "current" to the left of the equal sign as follows:

$$\text{Motor Current} \cong \frac{\text{Torque}}{\text{Field Strength}} \quad (3a)$$

This tells us that the amount of current demanded by a motor is proportional to the torque required to drive its load and inversely proportional to its field strength. Thus, if we maintain a fixed magnetic field strength (called "excitation") on the motor and increase the load, the motor must obtain a like increase in current in order to drive the load.

A generator is very similar to a motor except it is used for an opposite function; that is, to convert mechanical power to electrical power. In this case an engine turns the generator and it puts out electric power. It is based on the principle that when an electrical conductor is moved through a magnetic field, a voltage is induced or "generated" in the wire. The magnitude of this voltage will be proportional to the speed with which the conductor is moved and proportional to the strength of the magnetic field. This is our second basic relationship:

$$\text{Generator Voltage} \cong \text{Speed} \times \text{Field Strength} \quad (4)$$

It explains why we could increase our output voltage in the hydraulic analogy above, either by speeding up the engine or by increasing field strength of both. Since a motor is actually generating an internal voltage when rotating, we can restate this relationship to predict the speed of a DC motor in terms of its voltage and field strength.

$$\text{Motor Speed} \cong \frac{\text{Voltage}}{\text{Field Strength}} \quad (4a)$$

For the sake of simplicity we will neglect the fact that voltage in the above relationship is actually internal motor voltage and differs from the measurable external or applied voltage by a small amount which is negligible except under stalled or near stalled conditions. This relationship, then, tells us the speed of a motor whose field is held constant can be varied by varying the applied voltage, or that reducing the field strength will increase the speed of the motor.

Generator Selection. When a DC motor's field is held constant, its speed is proportional to applied voltage from the generator, and its torque output is proportional to current from the generator. Drilling rig drives should provide definite limits on input torque and speed. This means a generator is required with the ability to limit its output voltage and its output current. Such a generator characteristic is called a "differential" characteristic.

Shunt Generator. Starting with a straight shunt wound generator as shown in Figure 4a we will show how the differential characteristic is obtained. The generator of Figure 4a has one field winding which is excited from an independently controllable source of power, usually a separate small generator called an "exciter." By varying the amount of current in the generator field, we can vary its

output voltage, but for any given field setting the main generator voltage tends to hold constant regardless of the amount of current drawn by a motor connected to it. This characteristic is shown to the right of Figure 4a. It limits the speed of a shunt motor by limiting voltage but does not limit torque without the addition of external current regulating equipment.

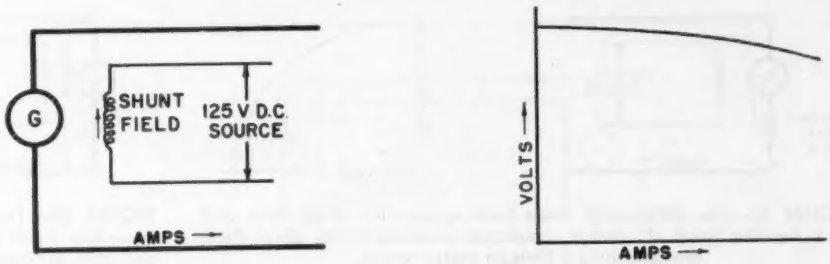


FIGURE 4a—Basic shunt wound generator with independent field excitation. For any given field setting the voltage remains constant regardless of the amount of current drawn from it.

Figure 4b illustrates a simplified version of a regulating system which has been used with this type of generator to make it suitable for the drilling application. An amplidyne is used to excite the generator shunt field. The operator adjusts the control field of the amplidyne to adjust motor speed. A voltage signal proportional to main generator current is compared with a current reference voltage and fed back into the current limit field of the amplidyne to oppose the control field. This has the effect of reducing the amplidyne output and hence main generator voltage as current increases. It causes the generator volt-ampere characteristic to cut off as illustrated. In order to recalibrate the current limiting circuit for lower currents at lower voltages it is necessary to also feed a generator voltage signal into the regulating system. The fourth field of the amplidyne is used to stabilize the system to avoid transient surges due to sudden changes in motor load etc.

Although the amplidyne is an extremely fast and accurate regulator and rugged and reliable enough for thousands of military and industrial applications, including reliable operation on drilling rigs, the accompanying circuitry has been considered too complicated for a drilling crew to understand and maintain. Other types of regulating systems have been applied to shunt generators on drilling rigs, but they all require similar complicated circuitry which is hard to understand and critical of adjustment.

Differential Generator. A far simpler method of accomplishing the same result is to add a series field in the generator itself, Figure 5a. This field winding, consisting of a few turns of heavy copper, is in series with the generator load current and is connected in such a manner that it opposes the shunt or control field. Thus, as current increases the series field becomes stronger and reduces the effect of the shunt field to reduce output voltage. At a limiting value of current, the series field completely counteracts the shunt field so that voltage is reduced essentially to zero. This represents all the current the generator will supply with the motor stalled and represents a corresponding limit on motor torque. The desirable characteristic is now inherent in the generator without any external regulating system to give trouble.

For drilling service, this generator can be further improved by the addition of a self-excited field winding connected across the generator itself. This field and its effect is illustrated in Figure 5b. It serves two major functions. First, it reduces the size of the separate excitation source because the generator now furnishes most of its own excitation. Second, it provides built-in overload protection for the driving engine. This is explained as follows:

Starting at Point A on the volt-ampere curve of Figure 5b, the engine is idling at governed speed, the generator is producing maximum voltage, but there is no load on the connected motor so that no current is required from the generator. Now, let us apply an increasing torque load to the motor. As it draws more current from the generator to develop more torque, the governor opens the engine throttle to maintain engine speed and produce the required power. At point B on the curve we reach full engine rating and the throttle is full open. As the motor demands more torque, or current, the engine can only slow down. But a slight decrease in engine and generator speed reduces the generator voltage because:

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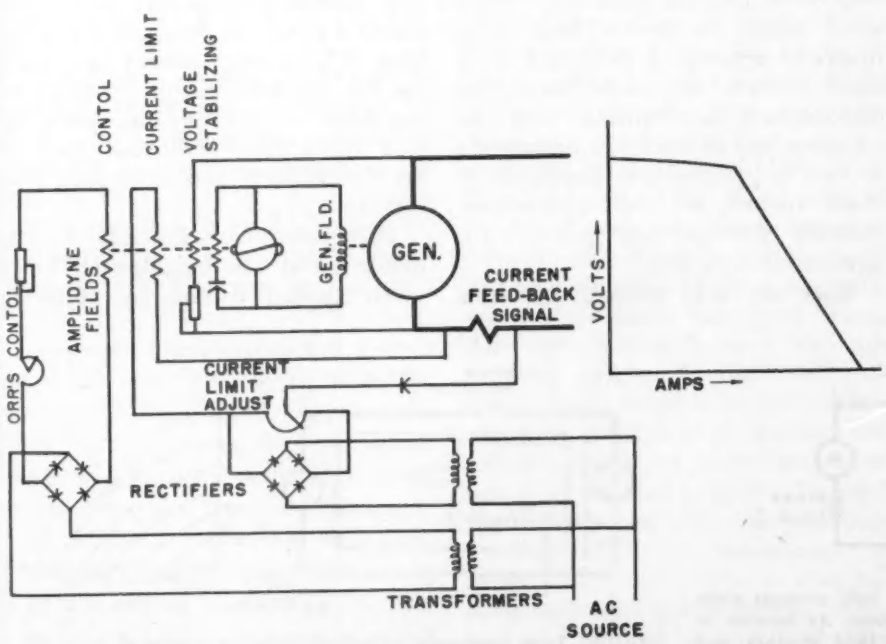

FIGURE 4b—Simplified version of amplidyne control system for use with the shunt generators for drilling rig application.

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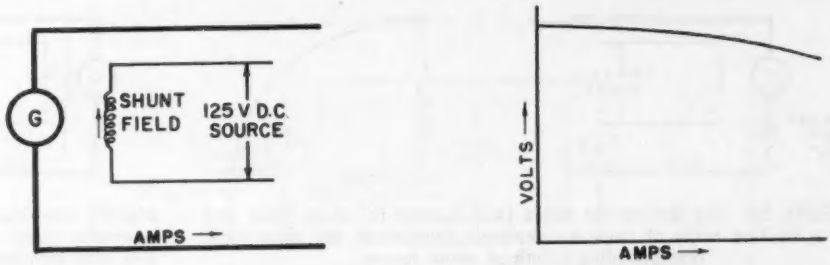

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For drilling service, this generator can be further improved by the addition of a self-excited field winding connected across the generator itself. This field and its effect is illustrated in Figure 5b. It serves two major functions. First, it reduces the size of the separate excitation source because the generator now furnishes most of its own excitation. Second, it provides built-in overload protection for the driving engine. This is explained as follows:

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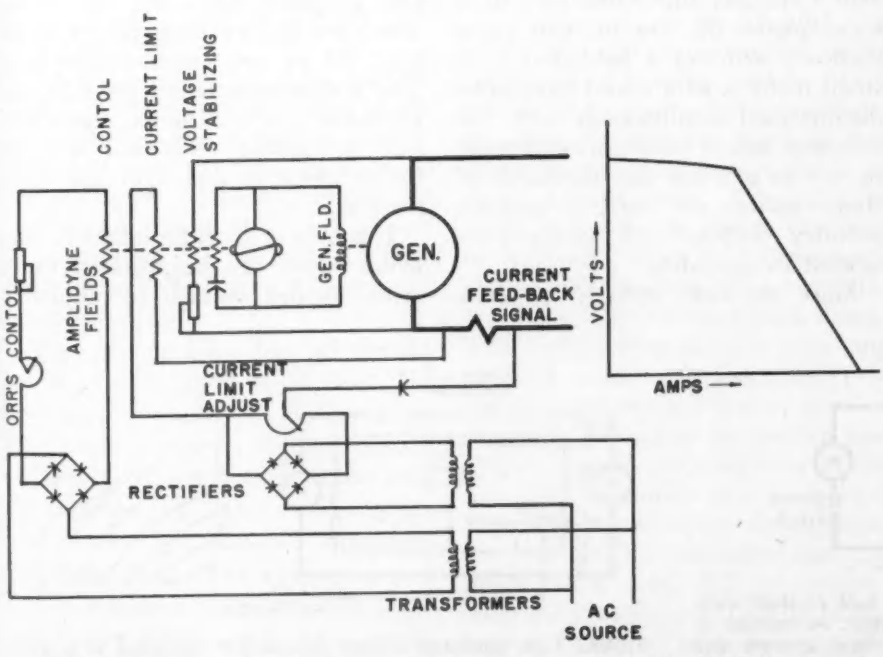
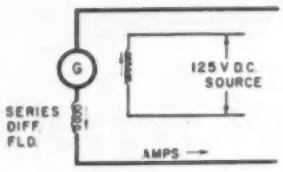


FIGURE 4b—Simplified version of amplidyne control system for use with the shunt generators for drilling rig application.



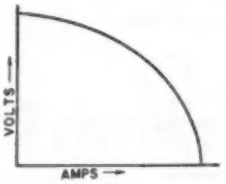
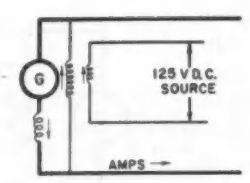


FIGURE 5a—The differential series field opposes the shunt field and at a limiting value of current completely counteracts the shunt field thus providing a limit on motor torque.



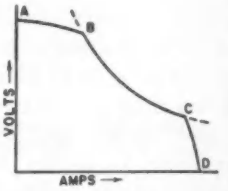


FIGURE 5b—The self excited field winding connected across the generator itself reduces the size of the separate excitation source and also provides built-in overload protection for the driving engine.

speed) reduce as the square of the reduction in engine speed. This means that the electric transmission would drop about 10 percent of its load if engine speed and load carrying capacity dropped 5 percent. The result is that a slight decrease in engine speed unloads the generator faster, and a balance condition is quickly reached where the generator adjusts its load to just match engine capability with no tendency to overload the engine. This condition exists as current increases to point C where voltage and motor speed are low enough to no longer require full engine power even though torque is still increasing.

From point C to point D the governor closes the throttle and at point D the engine is again at governed idle speed, the motor is developing maximum torque in the stalled condition but the series field has completely counteracted the shunt fields so only sufficient voltage is produced to circulate stall current. The process occurs in reverse if we now decrease the motor load and let it accelerate to maximum no load speed corresponding to the voltage at point A.

Motor Selection. A look at the motor equation, 4a, tells us that a motor whose field strength is held constant will always run at a speed dictated by its applied voltage, regardless of its load; and that speed can be limited by limiting voltage.

Equation 2 tells us that such a motor will demand current directly in proportion to its torque load and that torque can be limited by limiting current.

The only motor whose field can be held constant is a separately excited shunt motor, as shown in Figure 6a. The series motor shown in Figure 6b has its field excited by the load current. This means that if the load increases the field strength of the series motor also increases which tends to slow it down, and if the load decreases the field strength decreases tending to speed it up. It is obvious from Equation 4a that if a series motor loses its load for any reason (such as chain breakage) the field strength goes to zero and the speed tends to become infinite if any voltage at all exists on the motor. With series motors, external overspeed devices must be relied upon to remove power to prevent self-destruction on overspeed if load is lost.

It is likewise true that a shunt motor could overspeed if voltage were applied and field and motor load were lost simultaneously. In a series motor the loss of load automatically removes a field, but in a shunt motor a wire would have to be disconnected simultaneous with the complete loss of load—an occurrence so rare in practice that thousands of shunt motors are used throughout industry without any protection against overspeeding.

Since the field strength of series motors is always changing with load, voltage is no longer an indication of speed and the generator output voltage cannot be used alone to limit speed; nor will a voltmeter reading be proportional to speed. Likewise current is no longer proportional to torque and an ammeter will not read torque directly.

Until recently, shunt motors have been universally used on DC drilling applications and series motors were limited to geared traction applications. Even here, precautions had to be taken to protect the motors from damage due to loss of load. It is felt that safety demands shunt motors on chained or belted drives and performance and safety dictate their use where accurate speed control is required at light loads such as cat heading. Equation 4a shows that when field is held constant, as in a separately excited shunt motor, the speed will vary directly with the applied voltage which can be accurately controlled down to very low values. The presence of a fixed field on the motor is also valuable for deceleration purposes when the motor becomes a generator being driven by its load. Where series motors have been used it has been found necessary to improvise a shunt motor characteristic by adding additional controls for deceleration and light load performance.

It is evident from Equation 4a that motor speed can be adjusted for a given applied voltage by adjusting

FIGURE 6—The field of the shunt motor can be held constant while the series motor's field is excited by the load current. An increase in load on the series motor would increase the field strength and slow the motor down while a load loss would decrease the field strength and allow a speed to increase infinitely if voltage existed.

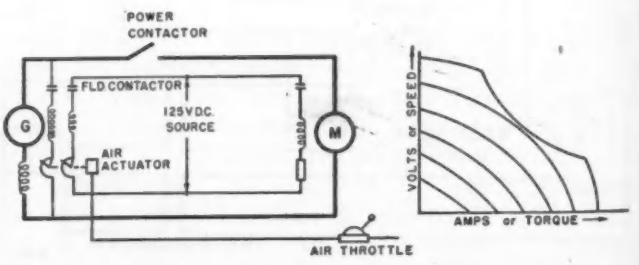


FIGURE 7—A separately excited shunt motor connected to a differential generator can be operated over the range of speed torque curves shown at the right.

the field strength. This is easily done with a tapped resistor in the motor field circuit. Increasing the motor speed by a fixed amount of field weakening merely shifts the speed-torque curve toward higher speed and maintains horsepower output constant. It is a valuable device for adjusting to sprocket ratio requirements or for tailoring the speed-torque characteristics to fit specific requirements. This will be more fully explained under the discussion of applications. The speed-torque characteristic of the shunt motor with the differential generator fits power requirements of drilling machinery as will be shown, and offers the important advantages of safety and maximum simplification of controls.

Controls. In Figure 7a, the separately excited shunt motor is connected to a differential generator through a switch or contactor. Contactors are provided to disconnect the fields, and a rheostat to control the generator shunt field strength and output voltage. By turning this rheostat we can obtain an infinite number of operating curves as shown. For a given setting of the rheostat, the motor operates up and down the selected speed-torque curve depending on the load imposed on it.

With no load on the motor, it would run at a stable speed at the left end of one of the curves depending on the setting of the rheostat. This speed could be varied at will from about 10 percent to 100 percent rated speed.

With an excessive load on the motor it would stall at a point at the lower end of one of the curves, developing a torque in proportion to the rheostat setting. This stalled torque can also be varied from about 10 percent to 100 percent of maximum generator current by the operator.

Thus the operator has full control of torque and speed at all times. He can apply torque gradually until the load starts to move, then accelerate as slowly or as rapidly as desired. Furthermore, a standard ammeter will provide a continuous indication of torque, line pull or pump pressure, and a standard voltmeter will indicate rotary RPM, line speed or pump strokes per minute. The product of volts and amps is watts which is converted to horsepower by dividing by 746.

$$HP = \frac{\text{Watts}}{746} = \frac{\text{Volts} \times \text{Amps}}{746} \quad (5)$$

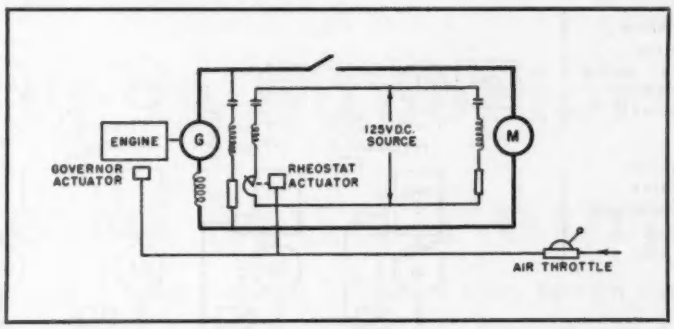


FIGURE 8—The field rheostat in the self excited field is eliminated and the air actuated rheostat controlling the separately excited field is controlled simultaneously with the engine speed from a common throttle at the drillers console.

Figure 7a illustrates the basic control scheme where the generator is driven at a constant speed by an engine. Voltage control is obtained by varying generator field strength. But from the basic equation for generator voltage, Figure 4, we could also control output voltage by changing the generator (or engine) speed. If we control generator speed we do not need as much field control to obtain the same family of output curves; so the rheostat plate is eliminated in the self-excited field and an air actuator is put on the other plate. This permits control of both engine speed and rheostat setting simultaneously from a common throttle valve at the drillers position. See Figure 8.

Actually, remote air operation is a convenient and simple way to control the rheostats in either system. Many drawworks already have provisions for such throttles for hand or foot operation or both, and drillers are familiar with them. They can be combined with air clutch operators or with each other in various ways.

The basic controls for one generator and one motor have been shown. The same system is used with any required number of machines, provisions being made to switch generators from one motor to another, and to put two or more generators on one motor for maximum power. Figure 9 illustrates a switching arrangement for four 600 hp generators and five motors each rated 625 hp continuously for pumping and capable of delivering 1000 hp intermittently for hoisting. Two generators driven by different engines are available to each motor to provide standby power for any function. All four generators could be used to develop 2000 hp at the drawworks, two generators in parallel on each motor.

An assignment switch for each generator is provided on the operators console. This sets up both the speed control and power circuits, and puts full field on all motors to which power is assigned. Thus, if power assignments were made as shown in Figure 9, Generator 1 would be assigned to drive the rotary, Generator 2 and 3 to Mud Pump 1, and Generator 4 to Mud Pump 2. If the throttle of Mud Pump No. 1 were advanced, the power contactors 2P1 and 3P1 would close, field would be applied to generators 2 and 3, and the throttle would control the output of these two generators, and consequently the pump speed.

The throttle system for this arrangement is also shown in Figure 9. When generators 2 and 3 assignment switches are set on Pump No. 1 (P1) position, the electrically operated air valves (2P1) and (3P1) are opened, connecting throttle (P1) to control generators 2 and 3. When this throttle is advanced the initial air pressure in the throttle line causes pressure switch (P1PS) to close its contacts which in turn closes power contactors (2P1) and (3P1) starting the pump. Similarly, generator 1 would be controlled by the drawworks throttle, and generator 4 by pump No. 2 throttle.

The power contactors are locomotive type, pneumatically operated, and rated to carry 1000 Amps continuously. They close on initial throttle movement and are opened by a spring when the throttle is turned off. They include blowout coils and arc chutes, and are capable of re-

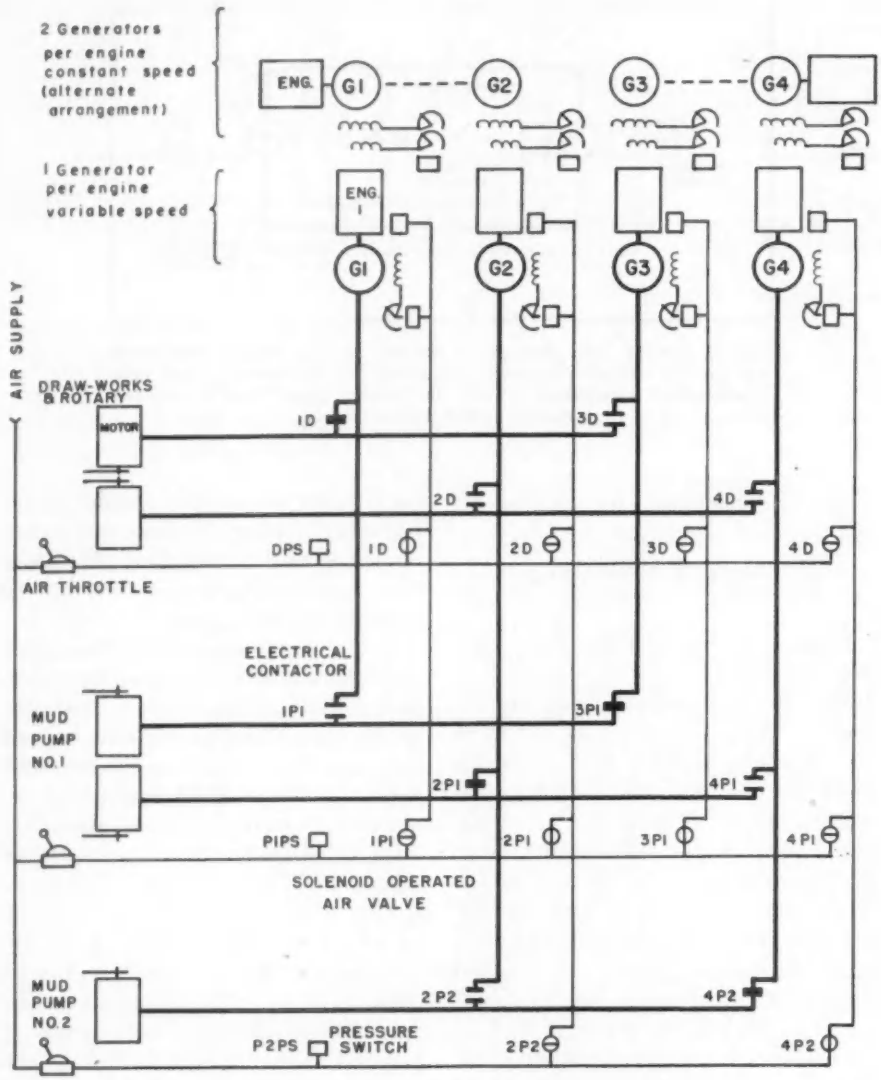


FIGURE 9—A schematic of the switching arrangement for four 600-hp generators and five motors each rated at 625-hp continuously.

peated openings while carrying maximum stalled current. They have been proven on severe locomotive duty and offer long, maintenance-free service on drilling duty.

Reversing of the drawworks or rotary drive motors is accomplished by turning a switch on the operators panel which merely reverses the shunt fields of these motors. This can be done with these throttles in the off position.

The above describes all the basic controls required for this system. It can be adapted to any combination of motors and generators with any desired degree of power assignment flexibility to suit mobile platforms, platform tenders and small or large land rigs. When two generators are driven in tandem by one large engine as shown alternately at the top of Figure 9, the generator fields only are controlled by the throttle, since a change in engine speed would change the output of both generators which may be connected to different loads. But separate controls can be provided to pre-select definite engine speeds such as idle, half, three-quarters and full, depending on power demand at the time. With one generator per engine or one generator driven by two engines, either system may be used, depending on whether it is desired to reduce engine speed automatically at reduced throttle settings or to provide separate engine speed controls.

A separate 125 volt DC source is required for power to generator and motor fields and control devices. This can be a single small auxiliary generator of 25 to 50 kw capacity depending on the size of the rig. It can be driven by one of the main engines, by a light plant engine or by an AC motor if sufficient AC power is available. Normally a second such auxiliary generator is provided as a standby.

Some protective features are included, as follows:

Emergency stop button—This is located on the operator's panel to shut down all power in emergency.

Electrical fault protection—One side of the power circuit is grounded through a sensitive ground relay. When an electrical fault occurs this relay operates to remove all power.

Cutout switches—Switches are provided at each pump, drawworks etc., which can be opened and padlocked if desired to prevent the application of power to machinery during maintenance or inspection.

Warning devices—Lights are provided on the operator's panel to signal loss of ventilation or ground relay operation. An alarm horn also sounds should a blower fail and the associated throttle is opened.

Engine shut down—If an engine shuts down for any reason, its associated generators are automatically isolated from the system to prevent running the engine by "motoring" action of its generator.

The operator's control panel includes the following devices:

- An assignment switch for each generator.
- An ammeter for each motor.
- A voltmeter for each motor where a speed indication is desired.
- A reversing switch for the draw works and rotary if separately driven.
- An emergency stop botton.
- Indicating lights as required.

The speed control air throttles may be mounted in the electrical operator's panel or separately on the draw works console.

This control system is purposely as simple as can be devised for controlling DC machines. It contains no complicated circuits or devices, but only contactors, relays, resistors and rheostats, plus the standard air devices which are familiar to the industry. All the devices are proven by years of locomotive service and the system has operated in drilling service with outstanding success.

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In the Wilson Chain Drive Mud Pump no sliding action, *only a rolling action takes place between the sprockets and the chain.*

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In the Wilson Pump the oil is first passed through a strainer, then it goes through a filter where even fine particles of sand or other foreign matter are removed before the oil is forced into the bearings, etc. Thus *all bearings and wearing parts are pressure lubricated with clean filtered oil, and should have a long trouble free life.*

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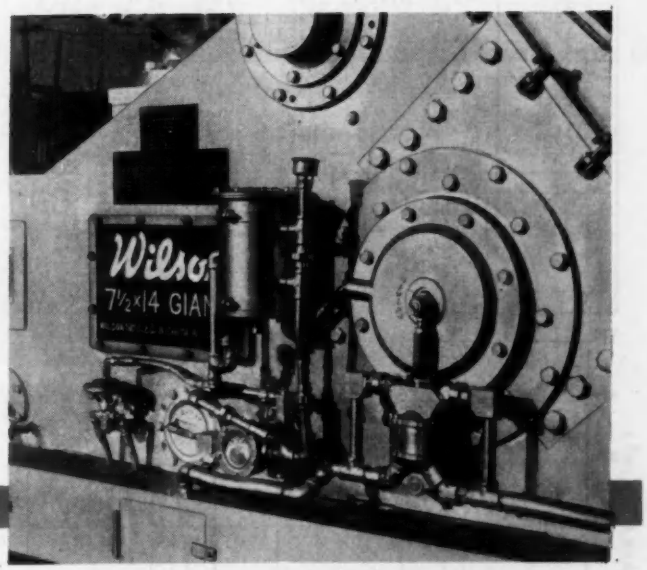
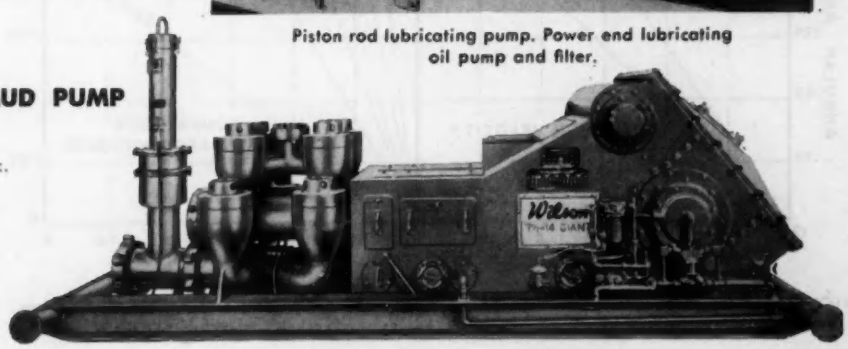
Wilson Engineers have gone all-out to give the industry a trouble-free pump that will mean longer and more efficient service with an absolute minimum of maintenance. The Wilson Chain Drive Mud Pump offers the operator real pump economy with more NEW and ADVANCED ENGINEERED features than any other pump on the market. Investigate the Wilson now and see for yourself!



Piston rod lubricating pump. Power end lubricating oil pump and filter.



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Two Years of Air Drilling Evaluated

Part 2—Air drilling has great possibilities, but its true potential to the drilling industry will be realized only if the necessary field information is taken, analyzed and used to initiate better techniques.

By LT. COMDR. JEROME A. REHBERG, SC., U.S.N.
Gardena, Calif.

BIT DIAM. (Inches)	DRILL PIPE DIAMETER (IN)							
	2 3/8"	2 7/8"	3 1/2"	4"	4 1/2"	5"	5 1/2"	6 5/8"
3 3/4"	6.63	4.57						
3 7/8"	7.35	5.29						
4 1/4"	9.79	7.73						
4 5/8"	12.35	10.29	7.14					
4 3/4"	13.39	11.25	8.10					
5 3/8"	18.24	16.18	13.05	10.08	6.75			
6"	23.86	21.80	18.65	15.70	12.37	8.64		
6 1/8"	25.01	22.95	19.80	16.85	13.52	9.79		
6 1/4"	26.27	24.21	21.06	18.11	14.78	11.05		
6 3/4"	31.37	29.31	26.16	23.21	19.88	16.15	12.02	
7 3/8"	38.25	36.19	33.04	30.09	26.76	23.03	18.90	8.24
7 5/8"	41.19	39.13	35.98	33.03	29.70	25.97	21.84	11.18
7 3/4"	42.76	40.70	37.55	34.60	31.27	27.54	23.41	12.75
7 7/8"	44.25	42.18	39.03	36.08	32.75	29.02	24.89	14.23
8 1/2"	52.34	50.28	47.13	44.18	40.85	37.12	32.99	23.33
8 5/8"	53.95	51.89	48.74	45.79	42.46	38.73	34.60	23.94
8 3/4"	55.72	53.66	50.51	47.56	44.23	40.50	36.37	25.71
9"	59.21	57.15	54.00	51.05	47.72	43.99	39.86	29.20
9 5/8"	68.27	66.21	63.06	60.11	56.78	53.05	48.92	38.26
9 7/8"	72.10	70.04	66.89	63.94	60.61	56.88	52.75	42.09
10 5/8"	83.84	81.78	78.63	75.68	72.35	68.62	64.49	53.83
11"	90.62	88.56	85.41	82.46	79.13	75.40	71.27	60.61
12"	108.69	106.63	103.48	100.53	97.20	93.47	89.34	78.68
12 1/4"	112.45	110.43	107.28	104.33	101.00	97.27	93.14	82.48
13 3/4"	143.04	140.98	137.83	134.88	131.55	127.82	123.69	113.03
15"	172.30	170.24	167.09	164.14	160.81	157.08	152.95	142.29
17 1/2"	236.12	234.06	230.91	227.96	224.63	220.90	216.77	206.11
22"	375.72	373.66	370.51	367.56	364.23	360.50	356.37	345.71
23"	411.07	409.01	405.86	402.91	399.58	395.85	391.72	381.06

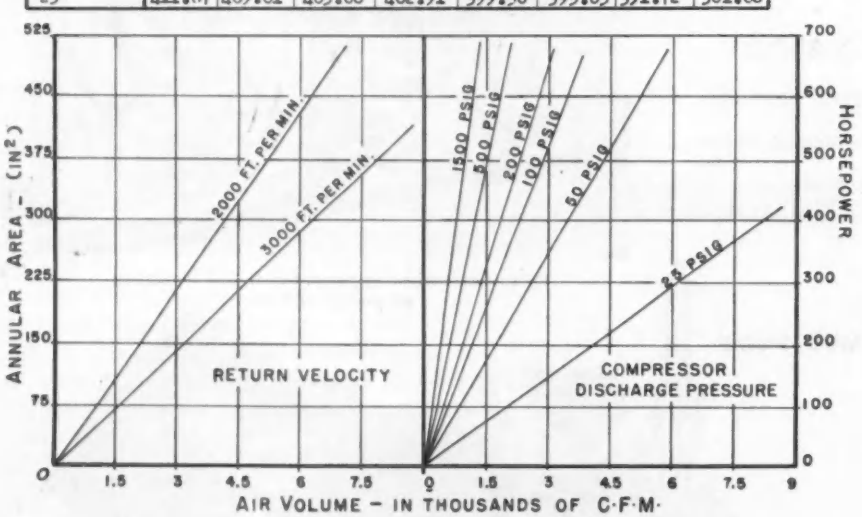


FIGURE 3—(Top) Annular area in inches$_2$ for various sizes of bits and drill pipe. (Bottom) Dry hole air requirements for return velocity method.

POWER REQUIREMENTS, along with many other aspects of air drilling should be subjects of further research.

In addition to the characteristics of air drilling presented in Part I, there are two additional characteristics of the utmost importance still remaining. These are (1) the removal of cuttings when air drilling dry formations and (2) the removal of cuttings when air drilling water bearing formations.

When air drilling dry formations the air or gas replaces the functions of the drilling mud on a standard rotary rig. The lifting capacity of the air stream must be sufficient to remove the cuttings without excessive regrinding. One approach to the air requirements problem was to determine the velocity required to lift a pre-determined size cutting.[3] The drag force on the particle is dependent upon its shape, area, the density of the flowing air stream, and the square of the air stream velocity.[4] Expressed in a mathematical formula:

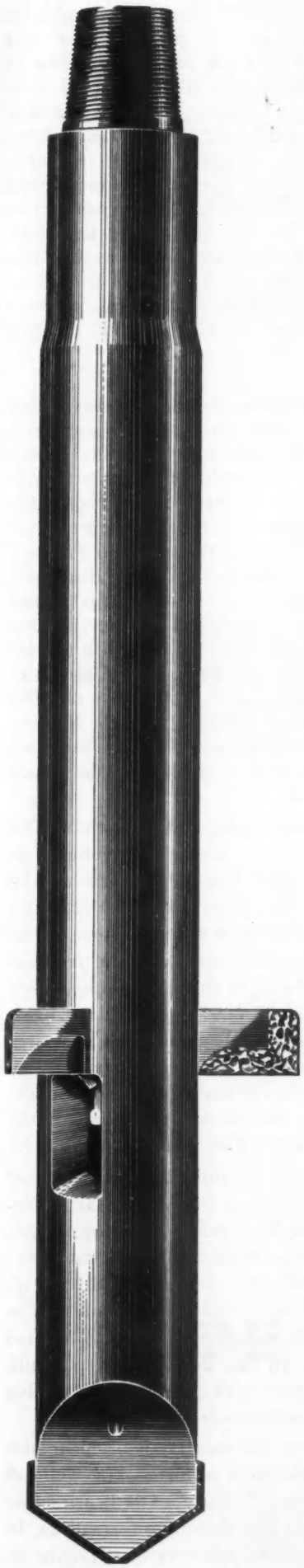
$$\text{Drag Force} = CA\,\frac{pU^2}{2}$$

where "C" is the drag coefficient, "A" is the projected area of the body on the plane normal to the flow, "p" is the density of the air stream, and "U" is the velocity of the air stream. The requirements are determined by equating the drag on the particle to the forces acting down on the particle. The downward force on the particle is gravitational force and is equal to:

$$\text{Gravitational Force} = \frac{\pi g D^3\,(\text{density of particle}—\text{density of fluid})}{6}$$

where "g" is the gravitational acceleration of 32.2 feet per second, and "D" is the spherical diameter of the particle. The cuttings are not exact spheres, but their shapes are sufficiently close to make the assumption of sphere-shaped cuttings an acceptable approximation.[3]

In the Appalachian area experience indicates that the optimum relation between penetration rate and horsepower requirements is obtained with a return velocity of air of 3000 feet per minute when drilling soft forma-



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tions, and 2000 feet per minute when drilling hard formations. Faster return velocities did not result in an appreciable increase in penetration rates, but the higher air volume requirements did increase the continuous horsepower output. Slower return velocities decreased the penetration rates, finally reaching a return velocity that was too slow to remove the cuttings. Using the return velocity as the criterion, the volume of air necessary to obtain the desired return velocity is dependent upon the size of the hole and the size of the drill pipe. The horsepower necessary to deliver this volume of air is dependent upon the discharge pressure of the compressor.

Figure 3, a composite of a chart and two graphs, was developed to give a rapid graphic solution of air volume and power requirements with the only necessary information being bit and drill pipe size. The chart in Figure 3 is a tabulation of calculated annular areas for various combinations of standard bit and drill pipe sizes. The graph, annular area versus air volume, solves the calculations necessary to determine the volume of air required in obtaining the desired return velocity. The other graph on Figure 3, air volume versus horsepower, solves graphically the power requirements for the compressor delivering the required volume of air at the discharge pressure. Figure 4 is composed of part of the two graphs from Figure 3 on enlarged scales for air volume and annular area, and should be used with low values of annular area or air volume for more accurate results. Friction loss was neglected in the computations, therefore, as wells become deeper some compensation for friction losses should be made. Experience data on friction losses in air drilling were not available. One article on air drilling recommended the addition of 20 percent to the volume requirements for every 2000 feet beyond a depth of 2000 feet.[5]

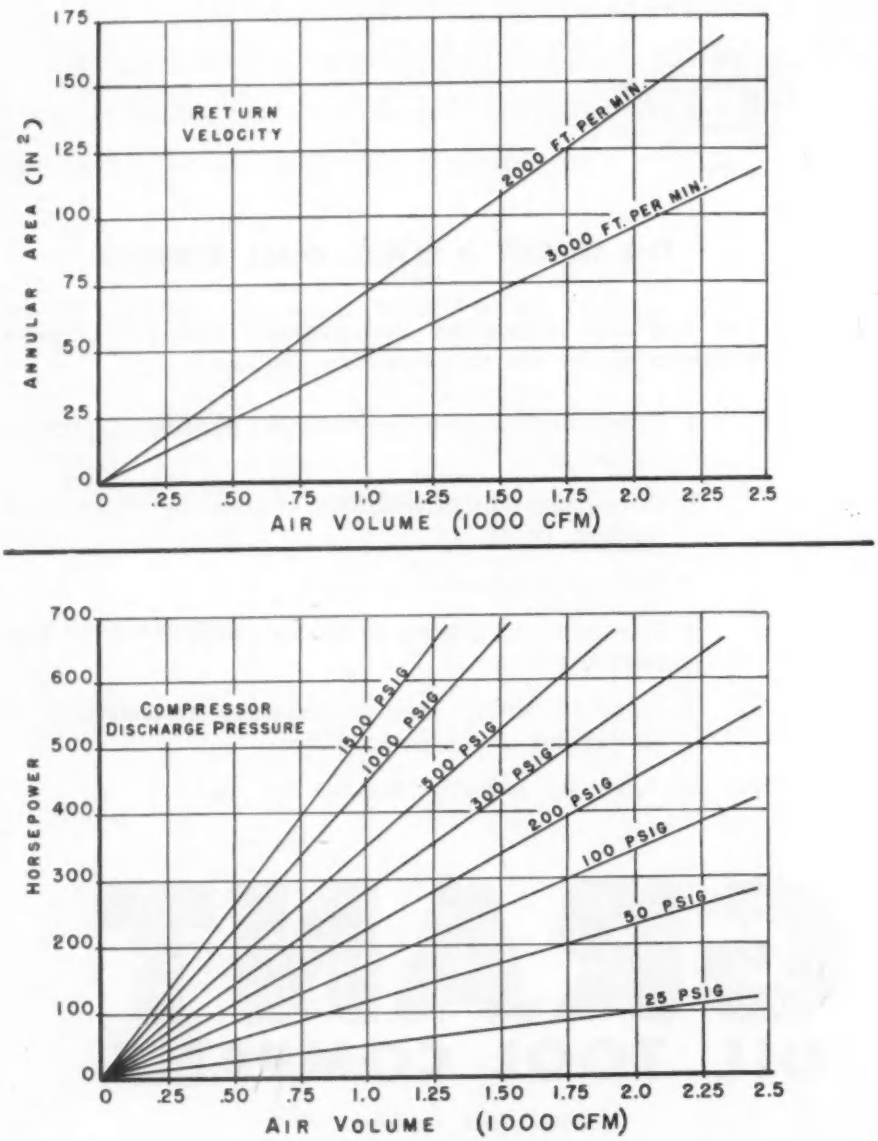


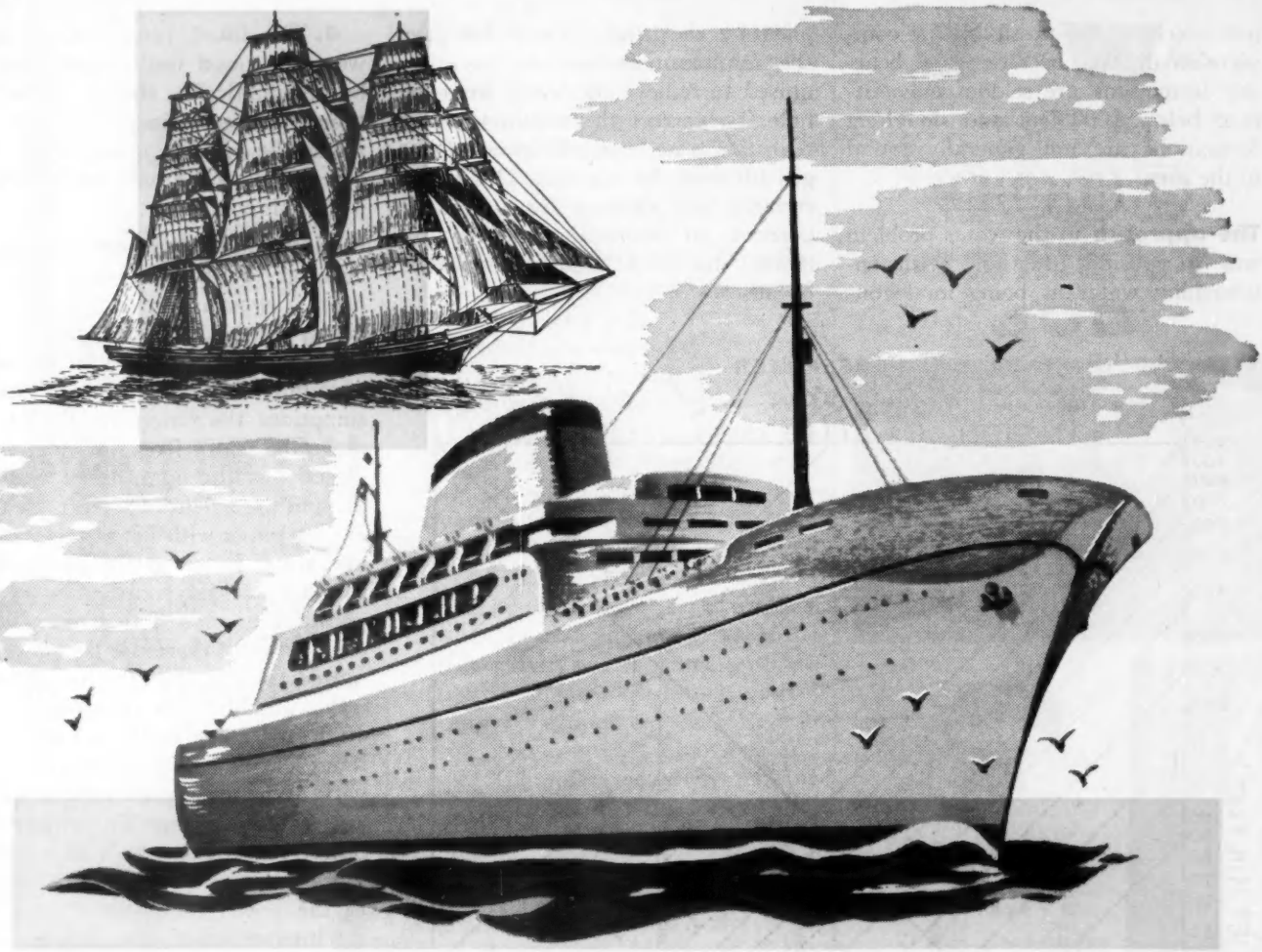
FIGURE 4—Expanded scale graphs from Figure 3 for more accurate readings with low values of air volume and annular area.

To illustrate the use of Figures 3 and 4, the conditions assumed are that a soft formation is being drilled with a bit of 8¾ inches in diameter on a drill pipe 4 inches in diameter. The compressor discharge pressure is 50 psig. Entering the chart on Figure 3 with the bit and drill pipe diameters, an annular area of 47.56 square inches is obtained. Entering the graph on Figures 3 or 4 with the annular area of 47.56, extend the value horizontally until it intersects the 3000 feet per minute line, from the intersection drop a vertical line to the abscissa of the graph and read the air volume required.

If drilling beyond a depth of 2000 feet, an increase in the volume requirement should be made at this point to compensate for friction losses. Entering the air volume versus horsepower graph with the required air volume, in this case approximately 1000 cfm at STP, extend the value vertically to the compressor discharge pressure line (50 psig), from this intersection extend a line horizontally to the ordinate and read the required horsepower value, approximately 113.

Of all the difficulties encountered in air drilling, the water bearing formations have posed the most onerous problem. Most drillers to date have "solved" the water problem by switching to high density muds, or in high fluid loss formations to aerated muds. In this investigation possibilities other than complete air drilling were not considered.

There are two factors which limit the possibility of air drilling wells all the way. They are water bearing formations and sloughing formations. In the Appalachian area these factors do



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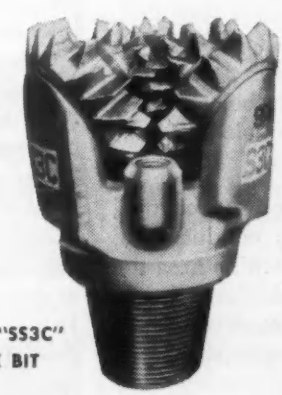

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not preclude the possibility of complete air drilling, because water bearing formations are seldom encountered below 1000 feet and sloughing formations are not generally found in the area.

The approach to the water problem was to consider the hole with encroaching water as being analogous to a well producing by gas lift through the annulus. An investigation of possible sources of information on the pressure gradients and friction losses of wells producing through the annulus revealed little. One authority on gas lift techniques stated that information on annulus gradients and friction correlations was not available.

The first step in determining the magnitude of power required to remove the water from the hole was to calculate the work necessary to lift a given quantity of water a specific number of feet. The weight of water was assumed to be 350 pounds per barrel. The weight of water multiplied by the height of the lift gave the minimum amount of work required to remove the water from the hole. To correct this minimum to a realistic value, the efficiency of the gas lift must be applied. This is extremely low, ranging from 5 to 60 percent. In developing the requirements, the lowest figure was chosen because:

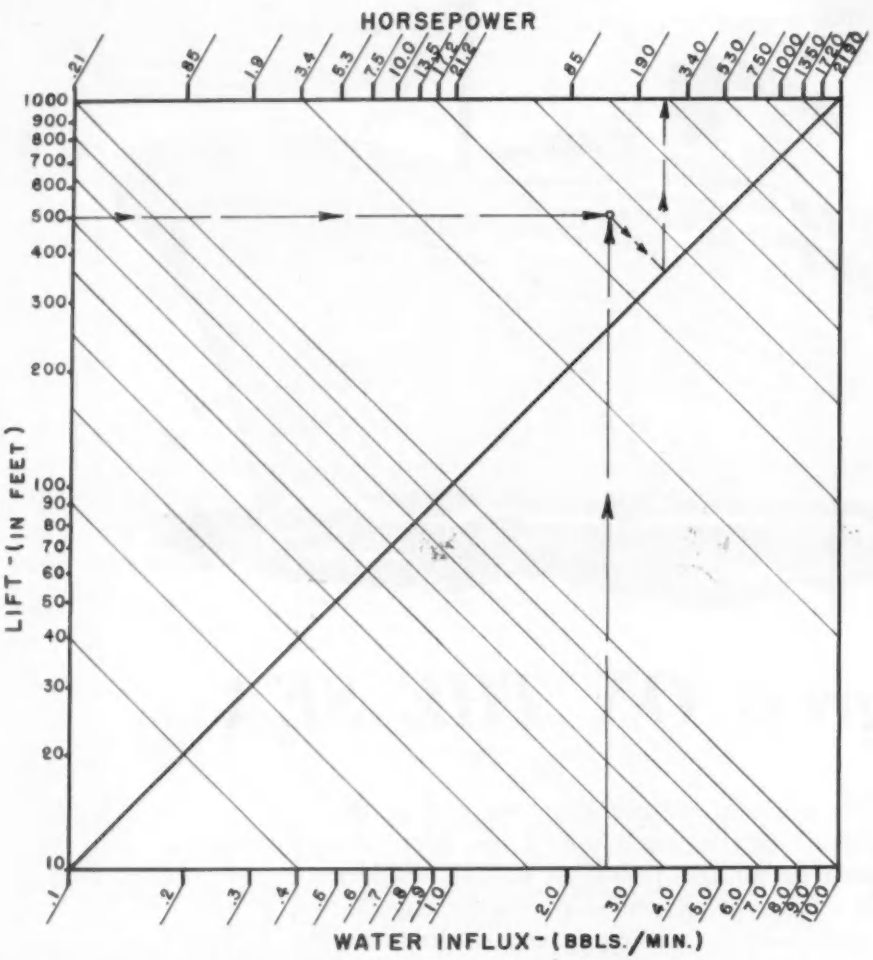

FIGURE 5—Idealized power requirements needed to remove water from the hole using air. Efficiency of lift is five percent.

1. Submergence is a factor in gas lift efficiency, and the point of injection in air drilling has, in most cases, very little submergence.

2. The large injection opening at the bit is inefficient as it permits the formation of large bubbles which have more slippage than smaller bubbles.

3. The large effective cross-sectional area in the annulus is conducive to slippage. In the Appalachian area the water bearing formations occur in the first 1000 feet of well depth where the annular area is the largest, and slippage the greatest.

4. The listed ranges of efficiency were for cased wells being produced by pneumatic lift, therefore, the frictional resistance in an uncased hole would be much greater than in a cased well with production through a smooth conductor.

In developing power requirements necessary to remove water from the hole, it was assumed that the efficiency of the lift was 5 percent and that the specific gravity of the water encountered was one. With these assumptions the power required to remove the water from the hole varied directly as the quantity of water to lift and the height of the lift. By using log log paper with lift as the ordinate and water influx as the abscissa, the product of the coordinates of any point falling on a 45-degree line was a constant, and therefore the power required for the combination of water influx and lift from any point on that 45-degree line was also a constant. A series of 45-degree lines was drawn with each line representing a specific power requirement. To project these power requirement lines to a scale, a single diagonal was drawn 90 degrees to the power requirement lines with the intersection of these lines projected vertically to the power scale. Figure 5, therefore, gives a graphic solution for the horsepower requirements for water removal at all the depths and rates of water influx encountered in the Appalachian area. To illustrate the procedure for determining the power requirements to remove water from the hole, the assumed depth is 500 feet with an estimated water influx of 2.5 barrels per minute. Figure 5 indicates a requirement of 265 horsepower for these conditions. This value is found by extending the depth value horizontally from the ordinate and water influx value vertically from the abscissa until they intersect.

From the point of intersection project a line parallel with the 45-degree lines until it intersects the single heavy diagonal. From this intersection project a line vertically to the horsepower scale and read the horsepower requirement; in this instance 265. The horsepower requirements obtained from Figure 5 may be converted to cubic feet of air per minute by using the air volume versus horsepower graphs developed for Figures 3 and 4. In one instance where some actual information was available a water bearing formation was drilled at a depth

of 900 feet using approximately 2200 cubic feet of air per minute at a pressure of 150 psig. The air volume versus horsepower graph of Figure 3 indicates a usage of approximately 450 hp which was slightly under the amount available from the rig.

Then from Figure 5 the water influx would be approximately 2.5 barrels per minute. This is not too far from what could be expected from the water bearing formations in the area. Unfortunately, the amount of water was not measured. The values obtained from Figure 5 are not meant to be a positive guide to the power requirements of all water problems. The values should only be used as a rule of thumb as certain factors would have to be modified for each case. For instance, in making up the graph the specific gravity of the water was considered to be one. Obviously most of the water encountered will have a specific gravity greater than one and also it will be increased by the fine cuttings dispersed in the water. Also, the efficiency of the gas lift was considered to be constant throughout the range covered by the chart, however as depth and quantity of water to be lifted change, the efficiency of the lift must also change.

Reverse circulation, at first glance, appears to have possibilities for water removal. However, most of the advantages of air drilling are lost with the use of reverse circulation. Footage drilled per bit decreases drastically, lost circulation becomes a problem, and bits are more easily plugged when reverse circulation is used.

When there is a likelihood of encountering water bearing formations, the driller must keep a constant watch for any signs of water in the cuttings. A little water in the cuttings causes the particles to become adhesive, but not wet enough to flow. The sticky particles build up on the drill pipe and well wall, restricting the flow of air and cuttings, finally building up enough to stick the drill pipe or to cause a twist off. In some instances the small water flows can be dried up by circulation of air without drilling.

In other cases more water must be added through the air stream to increase the "flowing" quality of the cuttings until other water bearing formations are encountered or until the water zones are passed and cased off. The graphic solution of power re-

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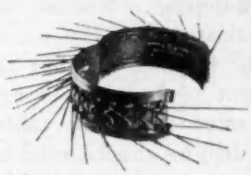

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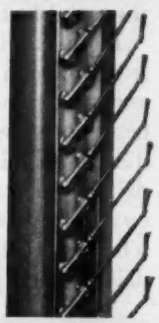

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quirements for water removal may be used as a guide in determining the limiting quantity of water that may be added and still be handled with the available horsepower at the depth of drilling.

Investigation of air drilling in the Appalachian area has indicated that its capabilities far exceed those of other drilling methods. Geologically the area is ideally suited for the use of air drilling. The two factors, sloughing formations and water bearing formations, which generally limit the application of air drilling are not prohibitive here. Sloughing is not a characteristic of formations in the area. The water bearing formations have production capacities ranging from 0.4 barrel per minute to 8.7 barrels per minute and occur in the first thousand feet of depth.

Figure 5 indicates that the water situation can be handled without an excessive amount of horsepower except for the most extreme cases. Therefore, air drilling can be used to drill wells from top to bottom without shifting to another type of fluid. The penetration rates obtained in air drilling are phenomenal when compared to other types of drilling, however, the investigation indicated that improved bit design would increase these rates.

Air drilling should make it profitable to penetrate deeper in the Appalachian area investigating the possibilities of lower producing zones. The air drilling rig is simple to operate and with strict adherence to ordinary safety precautions the hazards of air drilling are not excessive.

In conjunction with the operational characteristics, the economic aspects of air drilling are just as astounding. In a period of one year an air rig can drill 20 wells 6000 feet deep at a cost of $6 per foot. A similar rig using mud can drill 10 comparable wells 6000 feet deep at a cost of $9 per foot. Therefore, similar rigs with almost identical investments and but little difference in operational costs, have gross annual incomes that vary from $720,000 for air drilling to $540,000 for mud drilling. With moving to new locations involved a rig will not be on a hole continually, but the illustration points out the disparity that exists.

Air drilling in the Appalachian area has proved to be the fastest and most economical method of drilling. It can no longer be considered an experimental technique, on the contrary, it is quite capable of competing with the other methods of drilling. Cable tool drilling has approximately the same contract price per foot as air drilling but only to a depth of 5000 feet. Beyond that depth the cost of cable tool drilling goes up more rapidly than air drilling. In addition, the cable tool method is completely out of competition if time is an important element.

Any economic advantage brought about by air drilling does not give the drilling industry any reason for complacency. Competition is not limited to the development of new techniques and the improvement of old methods within the drilling industry. The whole industry is being challenged by the tremendous research and development efforts of the synthetic fuels industry. From 1945 to 1954 the drilling industry spent approximately $55,000 on research.[6]

During the same period the oil industry and the United States Government spent over $10,000,000 in research and development of shale oil.

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The improvements of drilling techniques should not be left entirely to ingenuity and chance. If drilling and development costs of finding natural crude exceed the development costs of synthetic fuels, then the drilling industry will necessarily wane, for no operator can reasonably be expected to gamble on the possibility of obtaining natural crude when he can positively get synthetic crude at the same price.

It is recommended that the drilling industry sponsor, perhaps in cooperation with the operators, an extensive and intensive research and development program to find new methods and to improve the old methods. In conjunction with this program, all problems that could effectively be done by engineering departments of colleges and universities should be assigned to them on a contract basis. This would not only accomplish the research, but would stimulate the interest of young engineers in petroleum production problems. It is further recommended that such a research program include the following projects for air drilling:

- A study of the expulsive forces on the drill column when completing a high pressure well and the best method of controlling the expulsive forces.
- A research program to determine the most suitable bit design for drilling water bearing formations and for drilling dry formations.
- A study of the friction losses encountered in the circulating system of air drilling with respect to depth and annular area.
- A research program to investigate the use of chemical mists for sealing water bearing formations.
- A research program to improve the efficiency of removing water from the hole.
- A research program to develop a method for continually recording pertinent geological information from the cuttings.

It is recommended that a program be initiated to instruct drillers in the importance and necessity for taking complete and accurate quantitative information in the field. Such information for air drilling should include the air volume being used, for correlation with depth, type of formation being drilled, compressor discharge pressure, bit and drill pipe size, type of bit, and penetration rate; the quantity of water being removed from the hole when water bearing formations are encountered; and the pressure of the line where the cuttings are discharged. Air drilling has great possibilities, but its true potential to the drilling industry will be realized only if the necessary field information is taken, analyzed and used to initiate better techniques.

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ACKNOWLEDGMENT

This two-part article is based on an investigation conducted in preparation of the thesis submitted to the graduate school of the University of Pittsburgh in partial fulfillment of the requirements for the degree of Master of Science.

The author wishes to express his appreciation to Prof. Holbrook G. Botset, Head of the Petroleum Engineering department, University of Pittsburgh, for his helpful advice and to H. J. Magner, of Delta Drilling Company, for extending the use of drilling data and for his generous assistance and cooperation.

In addition the author is indebted to the U. S. Navy Bureau of Supplies and Accounts and the U. S. Naval Postgraduate School for making possible his participation in the petroleum engineering course at the University of Pittsburgh and the practical training with Richfield Oil Corporation.

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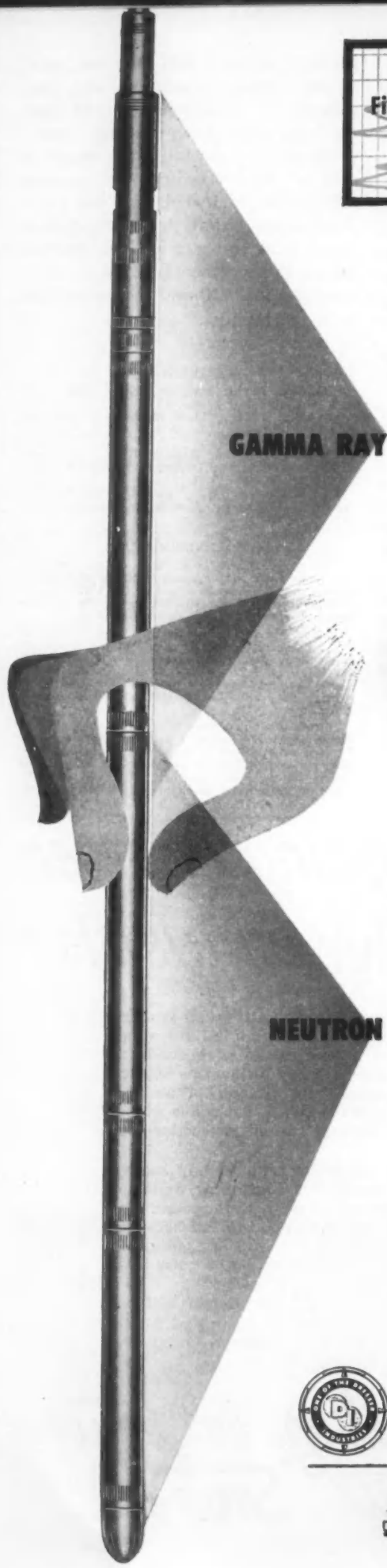

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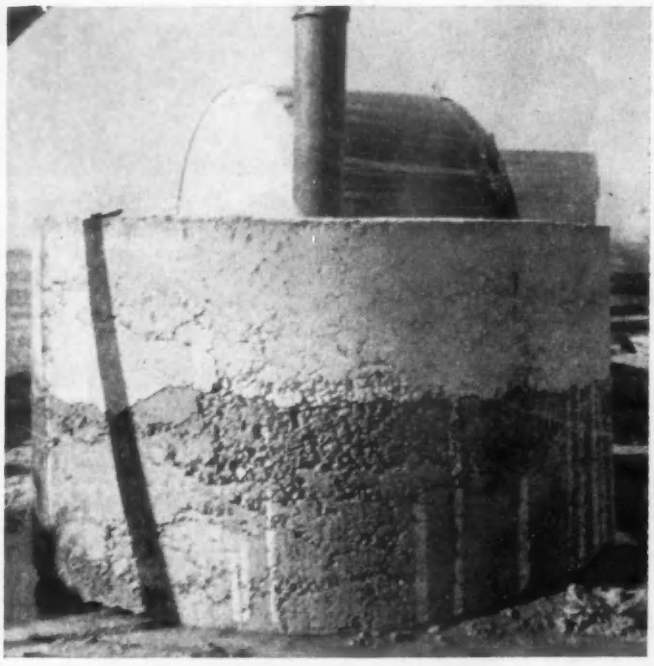

FIGURE 1—Typical horizontal fracture resulting from application of the new process. The concrete cylinder, fractured in a field test, was 3 feet high and 5 feet in diameter with 5½-inch J-55 casing cemented.

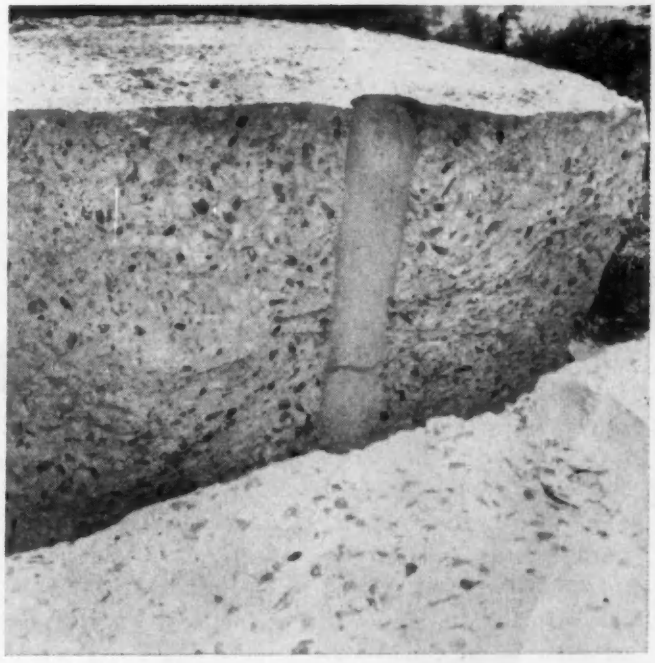

FIGURE 2—Here is result of a field test on a concrete cylinder after fracturing with the tool modified to produce a vertical fracture. Notice holes initiating from simulated well bore are in a vertical plane.

Horizontal Fracturing Controlled by New Process

A new process developed for use in new wells controls fractures in thin reservoirs.

A HORIZONTAL fracturing process using a new concept in creating and controlling stress patterns and ultimately the line of fracture has been developed and field tested in West Texas. The process has been used in 52 field tests over a two-year period. With this control, it is possible to develop horizontal fractures in a near uniform plane and control the point of initiation. The company maintains this is the first successful attempt to control the plane of fracture since fracturing was first introduced. This article describes the process with its capabilities and limitations based on field testing.

The process is restricted to use through casing in new completion zones that have not been perforated. Zones previously fractured, squeezed, or heavily acidized would also be eliminated as the stress pattern set up by these processes could possibly be affected and unselected intervals be broken down.

Field tests and studies have previously shown that a deep penetrating fracture will provide more effective reservoir drainage than several shallow penetrating fractures in each zone of permeability. With the new process it is possible to initiate the fracture at a selected point, eliminating the need to perforate a complete zone. Controlling the fracture in thin zones keeps the fracture in the producing zone and out of an adjacent gas or water bearing zone, resulting in lower gas-oil and water-oil ratios. Four other advantages of the process are:

- Penetration through thick cement thickness.
- Reduction of vertical communication outside the casing.
- Less holes are required for communication between the well

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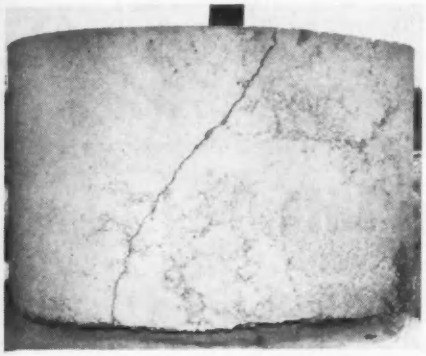


FIGURE 3—The tool can be modified to produce angular fractures. Shown here is a near 45-degree fracture resulting when fracturing a concrete cylinder in a field test.

bore and the producing formation.

- Laboratory tests show that an induced fracture can cross intrinsic fractures during its extension as the concentration of stress at the extremity of a fracture is almost infinite.

The process is not successful in open hole treatments. This is based on the success ratio of 15 field tests in 100 to 200 feet of section. Of these 54 percent were considered successful and the remainder unsuccessful because undesirable results were obtained.

For practical application in the field, controlled stresses to induce fracture must be sufficiently intense that the fracture will occur between perforated holes before failure results on a weaker plane. Experimental work was necessary to develop a spacing between holes to produce the desired results in the majority of applications. Number of holes, depth of holes, hole diameters, and hole spacing are factors that would vary with the type of formation and depth. It was necessary to determine these factors for various formations in developing the new tool and process. The process uses a stress concentration produced by creating two sets of three holes on a horizontal plane.

The company's experimental laboratory work showed three parallel holes, properly spaced, when fractured hydraulically will fracture simultaneously between each set of holes.

The tool itself, 4.4 inches O.D. with 1⅛-inch O.D. charge case and 1-inch O.D. cone charge, uses an 8 to 10 gram charge comparable to the jet. Made of drillable aluminum, shown in its component parts in Figure 4, it is blown into small fragments when detonated. After firing, conventional frac treatment can be employed.

The process can be modified for use in vertical and angular fracturing based on field tests by the company's research group. Vertical fracturing was successfully performed in a field test on a 3-foot high and 5-foot diameter concrete cylinder with 5½-inch J-55 casing cemented in the center. Modification of the tool for this condition was necessary to produce two sets of three parallel holes in a vertical plane. A similar test with the tool designed to produce a 45-degree fracture was also successful in a field test with the same size concrete cylinder and casing.

This process to control vertical and angular fracturing is desirable where multipay sections are separated by thin shale beds and where dipping beds are present.

FIGURE 4—New tool used to initiate the point of horizontal fracture.

In the company's 52 field tests, the maximum injection rate has been 20 barrels per minute at 900 psi. Another well was fractured with 90,000 pounds of sand at 1400 psi. The highest sand concentration used in frac fluid in these tests was three pounds per gallon.

This new concept in fracturing, although in its infancy, has many applications within the industry and is expected to be watched with interest as further development and scope of application is increased.

—The End

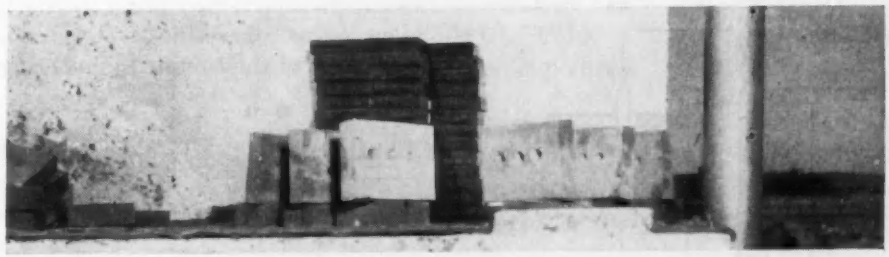


FIGURE 5—Photo at top shows one-inch steel plates after detonation of the tool. The three parallel holes in each plate illustrate the hole spacing and tool's penetration necessary to obtain horizontal fracture control from the point of initiation desired in well. Lower photo shows tool in firing position in a testing pit with one-inch steel plates on each side.

For Your Production File . . . (Part 1)

'Graph System' Gives Gas Lift a Lift

A quick, simple and reliable graph system for designing gas lift installations and subsurface plunger applications has been devised. It reduces hours of work to minutes and extensive calculations to a matter of plotting.

By E. D. McMURRY
McMurry Oil Tool Specialties, Inc.
Houston

THE GAS LIFT method of producing oil is a process using either high pressure gas from available wells or compressed gas as a lifting medium. Its use has become widespread and it is a flexible process. Production engineers must become as familiar as possible with gas lift installation design to be able to evaluate lifting methods effectively.

Graphs A through H will be presented with Part 2 of this series. These graphs are used for the design of different types of installation procedures for four well conditions.

Gas lift installation design is not as complicated a procedure as one is often led to believe. For a start, consider some of the common misconceptions regarding gas lift installations which cause confusion.

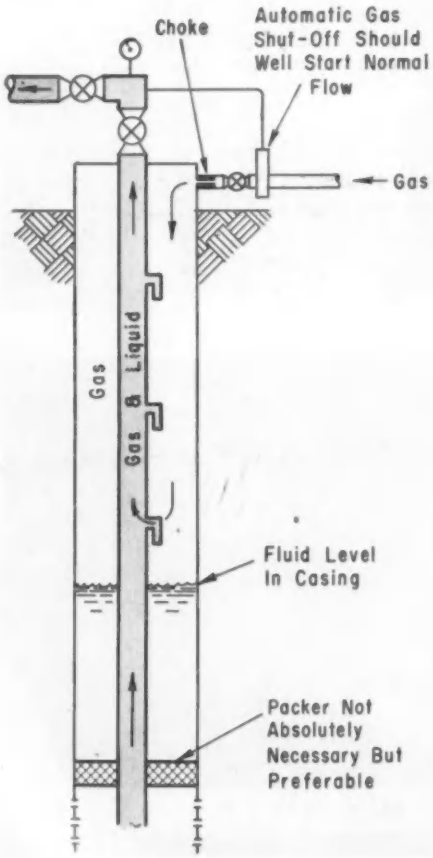


FIGURE 1—Typical constant flow installation from tubing. Used on wells with high productivity index. (Production rate 250 barrels daily or more.)

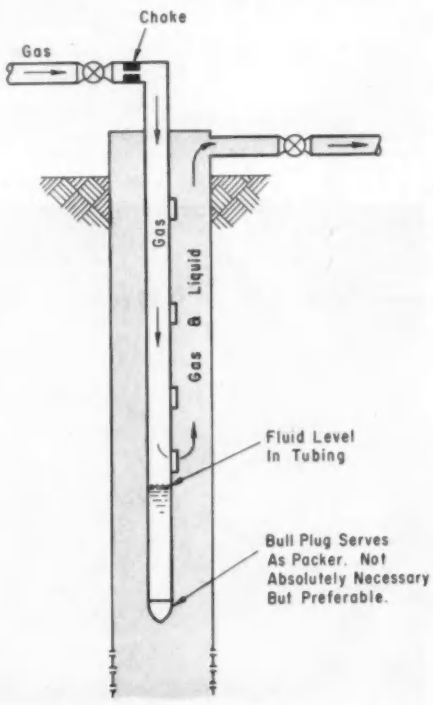


FIGURE 2—Typical constant flow installation from casing. Usually applied where 2000 barrels daily and up to 20,000 barrels daily are required.

The term "constant-flow" gas lift usually is applied to that type of installation used on wells of the high bottom hole pressure and high productivity index category.

Gas is injected into the flow string at a more or less constant volume and pressure. Fluid recovery is also at a relatively constant rate.

The constant flow installation finds its best application in wells where it is necessary to handle over 250 barrels of fluid daily to obtain allowables. Figure 1 and Figure 2 illustrate this condition.

Intermitting Flow Gas Lift. This method of flow is used where wells have a limited producing capacity or where fluid requirements are small in total volume. Lift gas is injected into the flow string in surges (usually with a time-cycle intermitter) at different time intervals. Fluid recovery is in surges.

Normally this type of gas lifting is applied to wells producing less than 250 barrels daily. A sample illustration is shown in Figure 3.

"Stop-Cock" Flow Gas Lift. This method differs from other gas lift installations in that the tubing remains shut in a considerable period of each producing day. A time-cycle or pressure-controlled motor valve is mounted on the flow line at the christmas tree. At predetermined periods this tool is made to open allowing the well to produce the fluid which has accumulated in the tubing during the shut-in time. No packer is used with this installation in the majority of applications, so that lifting gas both from an outside source or formation gas can be stored in the casing annulus.

This type of installation is used normally on those wells having a high bhp but low PI and usually produc-

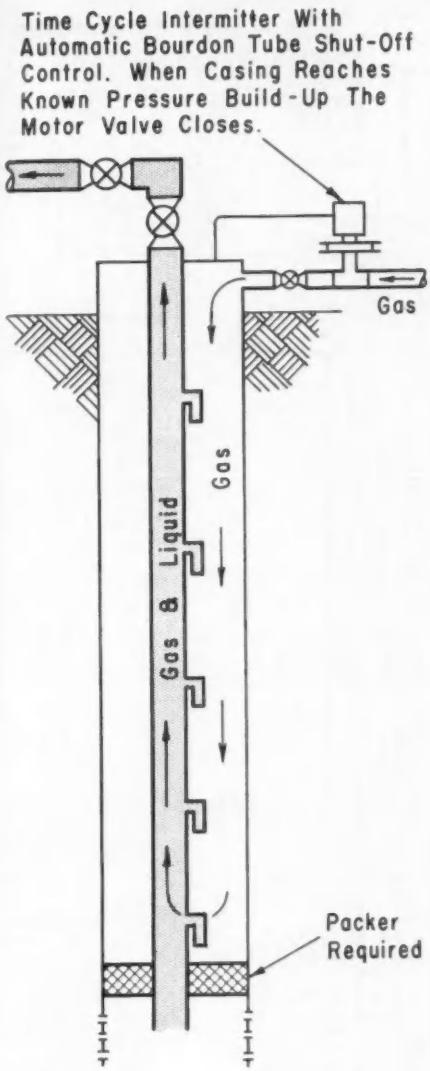


FIGURE 3—Typical intermitting installation. Used on wells with low to poor productivity index where total production is not to exceed 250 barrels daily. A subsurface plunger is sometimes used with this installation.

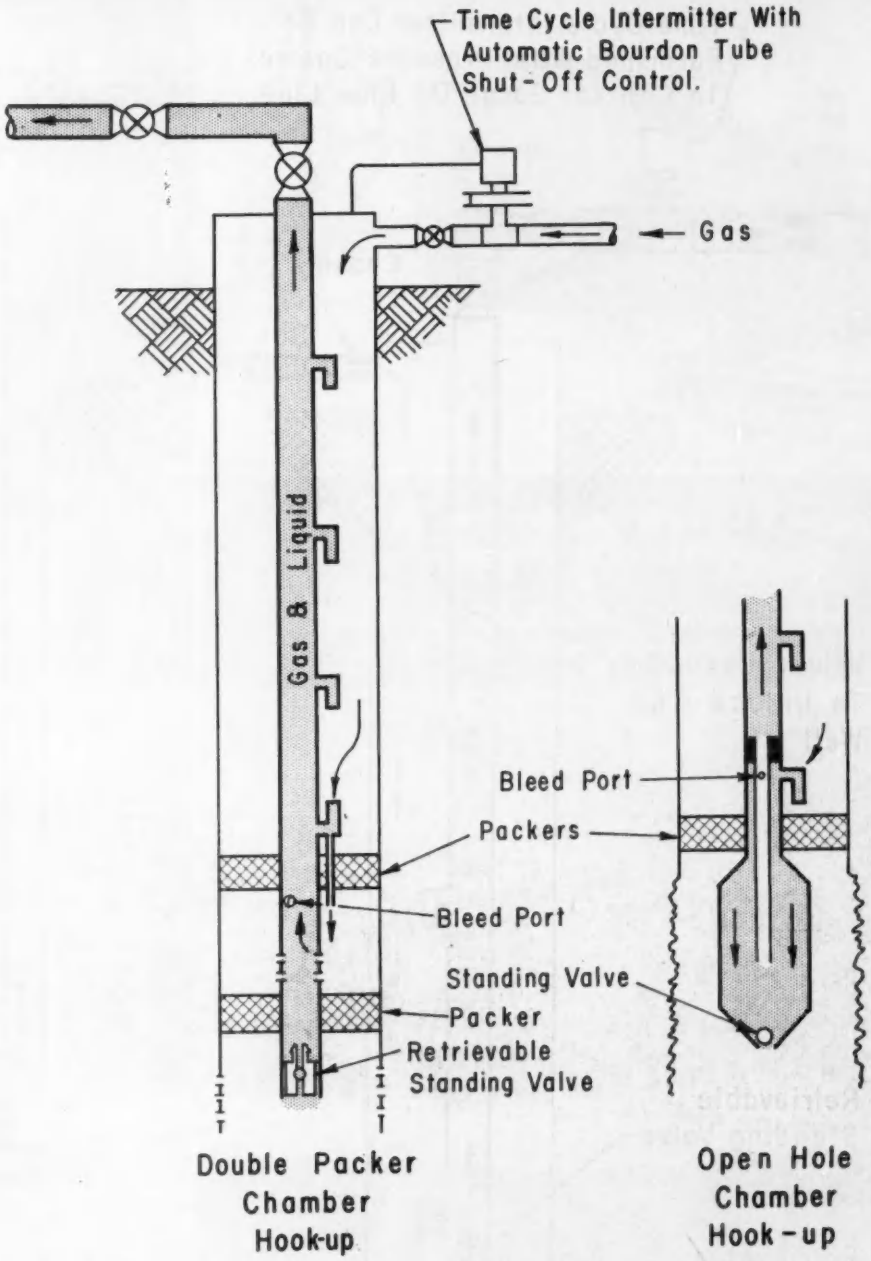


FIGURE 4—Typical chamber gas lift installation. In practice this type of installation is being replaced with the subsurface plunger which simplifies the downhole equipment.

ing less than 100 barrels daily (Figure 5).

A subsurface plunger is used in conjunction with this installation in many cases.

Outside gas is admitted to the casing at relatively constant rate whenever necessary.

Basic Types of Wells. By and large, almost all gas lift problems will be encountered in the following six types of wells.

1. High bhp and high PI, with very little, if any, anticipated reservoir decline. (This condition ordinarily is associated with active water drive reservoirs. Usually, these wells have a PI of .5, or more.)

2. High bhp and high PI, but with an anticipated rapid reservoir decline. (This condition normally found where reservoir is solution drive.)

3. High bhp and poor to low PI (less than .5). (This type of well is common to the solution drive type of reservoir and is, in many cases, semi-high to very high ratio.)

4. Low bhp and high PI (.5, or more).

5. Low bhp and low PI (.5, or less).

6. Dual or triple completed wells, either of which may fall under the above headings, as shown in Figures 6 and 7.

Note: A well normally is considered to have a low bhp when the static pressure is less than 200 (pounds per square inch) for each 1000 feet in depth.

General Information. Following are several points of information which will always be beneficial when designing gas lift installations. Of particular importance in this group are the productivity index, drawdown characteristics, static bottom hole pressure and flowing gradient.

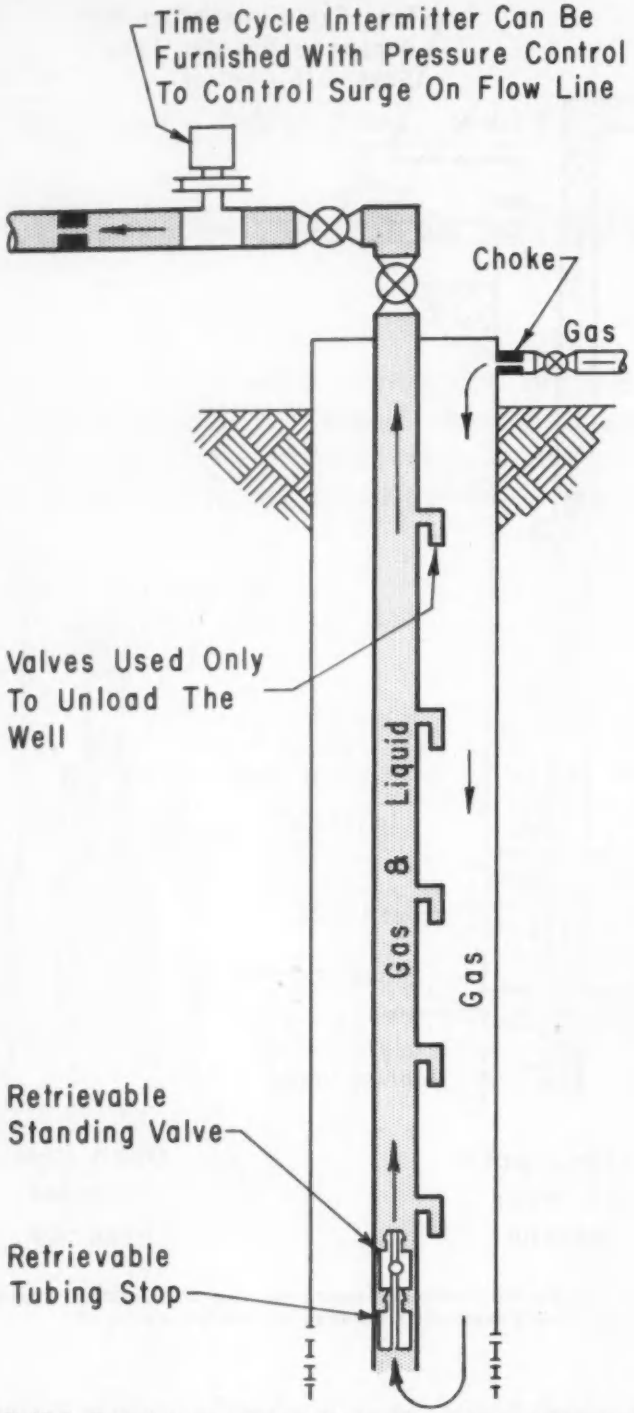


FIGURE 5—Typical "stop-cock" gas lift installation for high bhp, low productivity wells. Intermitter opens on predetermined time cycles to produce the accumulated fluid. In many cases a subsurface plunger is added to this installation. This basic idea is also used on many flowing wells of the high ratio class (300 cubic feet per barrel per 1000 feet depth or more).

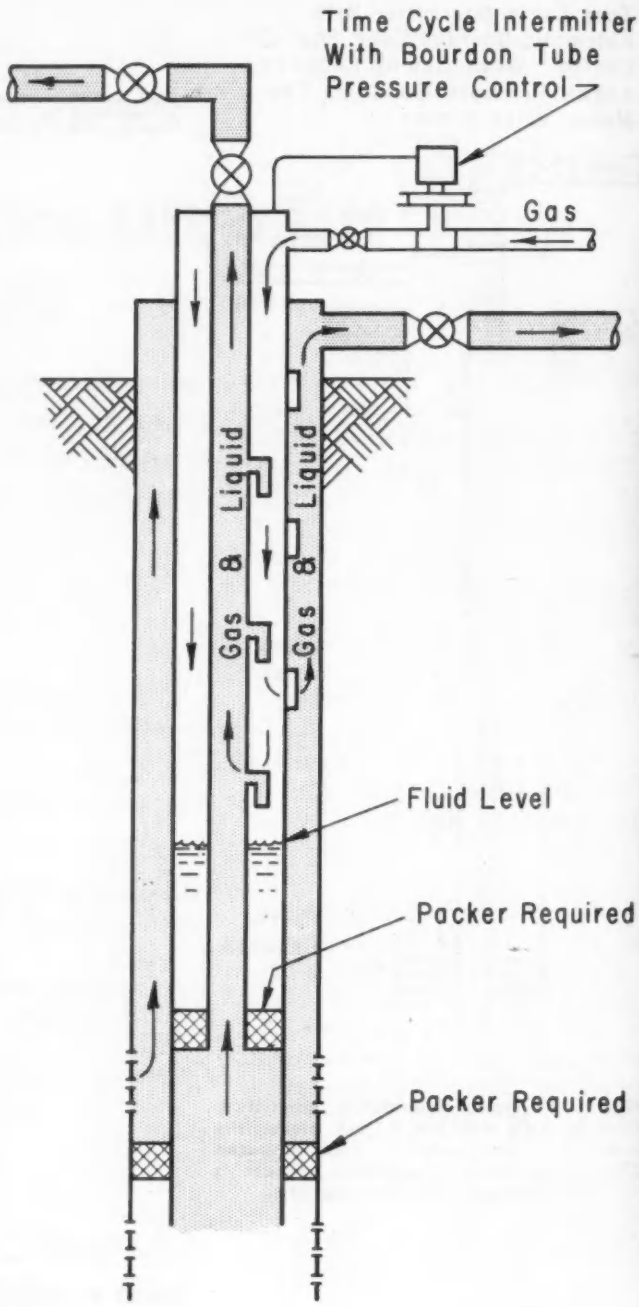


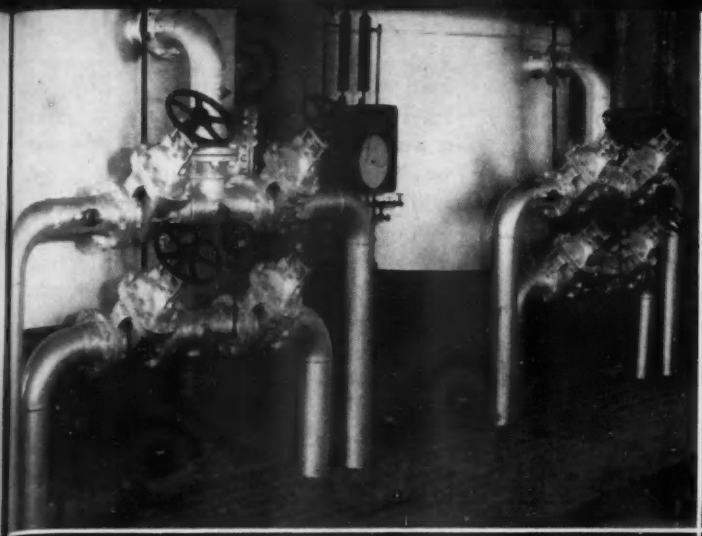
FIGURE 6—Typical dual installation with macaroni tubing. One string of valves is pressure operated, the other string is fluid operated, or both can be fluid operated.

If the functions of these are understood with relations to gas lift design, then the average time involved in an installation design may be a matter of minutes.

Productivity Index. [Barrels each 24 hours per (psi) sand face drop.] Accurate PI data is not always available when designing an installation. However, if it is possible to obtain some reasonable indication of the well's producing characteristics, a much better design will result. There is a very *definite difference* in an installation designed to handle 100 barrels daily versus one handling 400 barrels daily, or in turn, versus one handling 1000 barrels daily.

Drawdown Characteristics. If productivity data are available, they should be applied to only 50 percent of the static pressure of the well in order to obtain the approximate maximum rate of flow which could be expected under ideal conditions. The design of the installation should be based around this figure.

Only 50 percent of the static pres-



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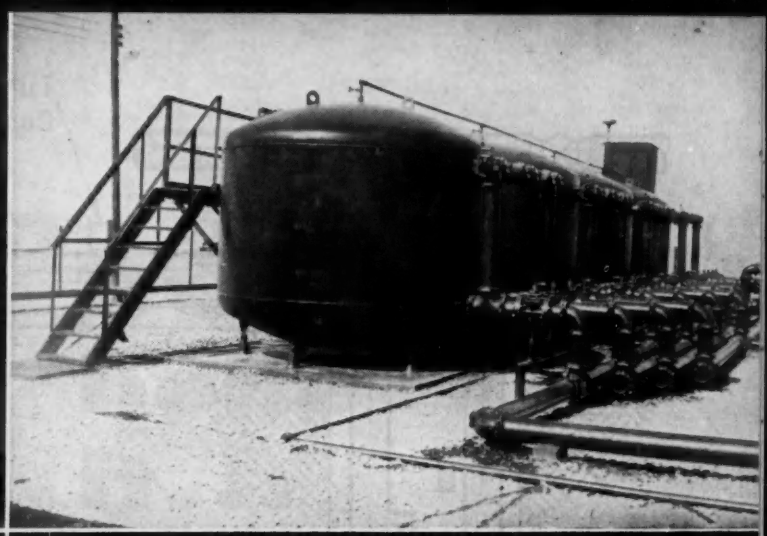

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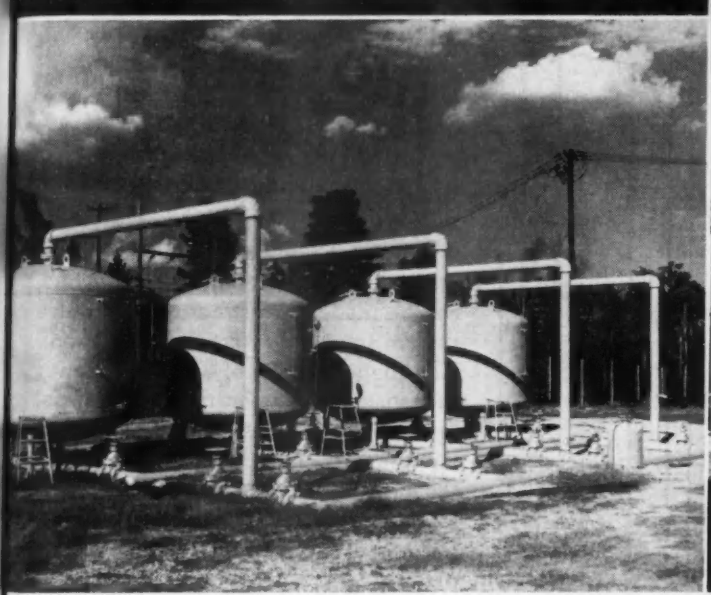

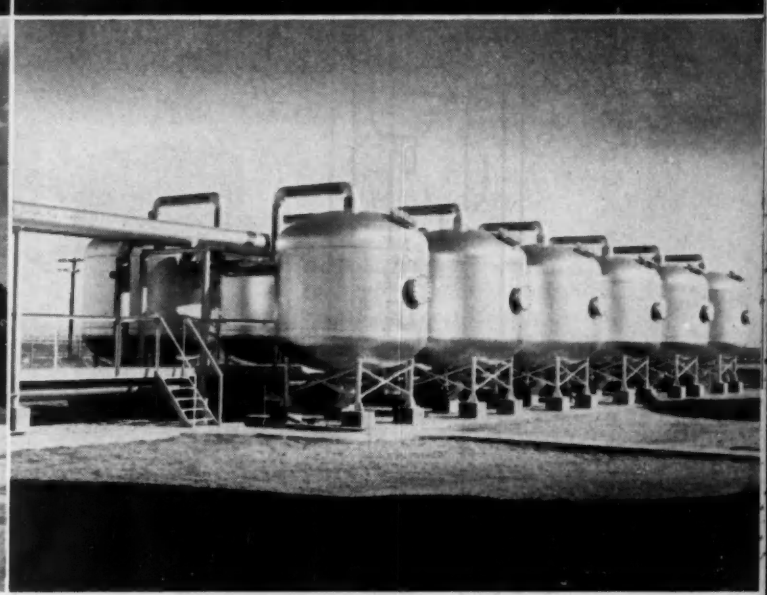

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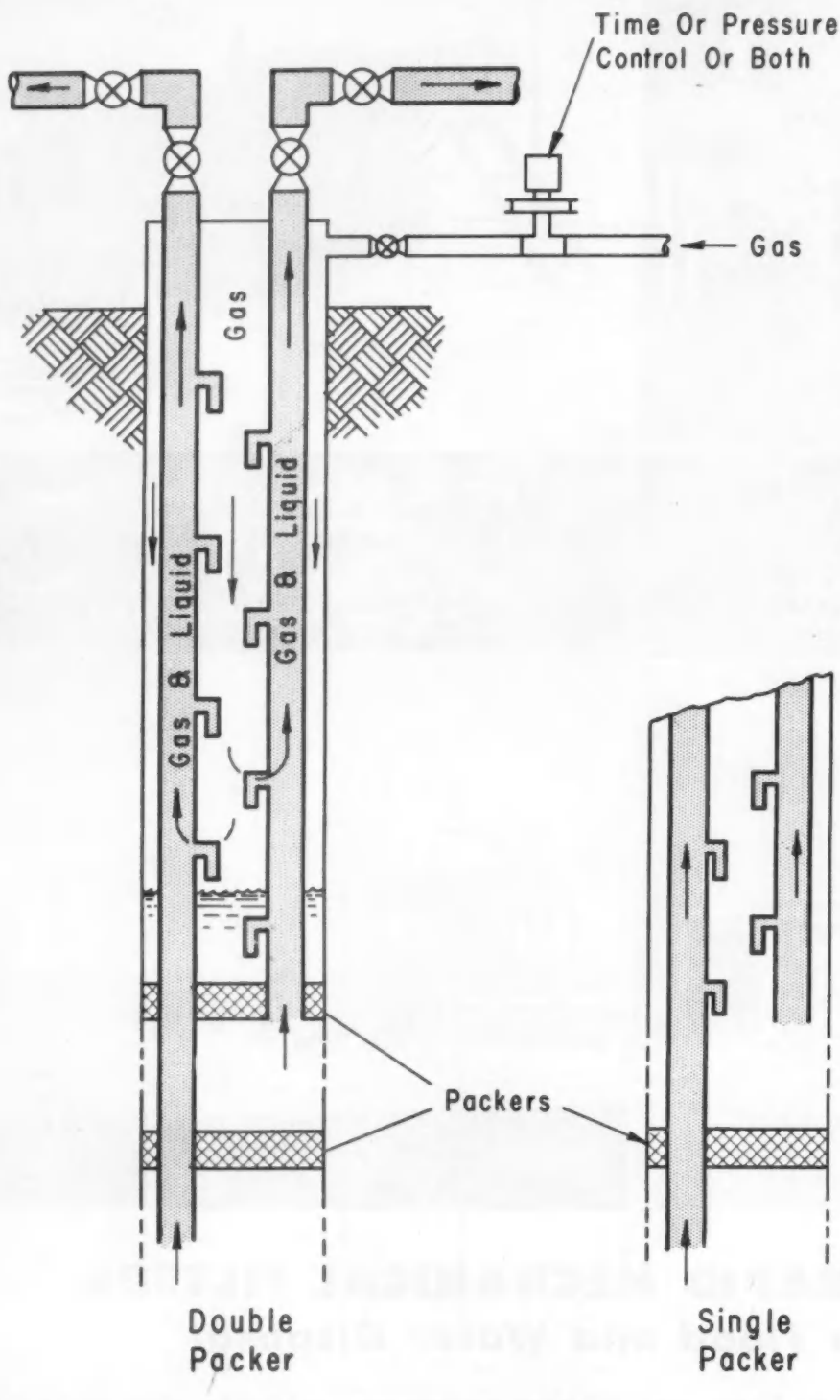

FIGURE 7—A typical tandem string gas lift installation. One string pressure operated valves, the other string fluid operated valves. In rare cases both strings fluid operated.

sure is used to establish the maximum rate because the PI is not a straight line function. Drawdown beyond 50 percent does not produce additional fluid of any consequence.

Static Pressure. The static bottom hole pressure and, in turn, the static fluid level will indicate where to place the top valve only in the installation. The spacing of all other valves is a function of the operating casing pressure in relation to the producing flowing gradient in the tubing.

Flowing Gradient. [Friction loss (psi) in tubing under producing conditions.] When producing with gas lift, whether it be constant flow or intermitting, the tubing string acts as a vertical pipe line. In any specific well at any given rate of flow there will be a certain minimum friction loss or back pressure (psi) always existing at the valve that is injecting gas. When designing a gas lift installation, this flowing gradient must not be underestimated if the installation is to give best results.

Spacing of Valves. The spacing of all valves below the top valve in the installation is a function of the operating casing pressure in relation to the flowing gradient opposite each valve as the well is unloaded progressively down the hole. Should the flowing gradient be underestimated, it becomes impossible to work past the valve where the flowing gradient (psi) is greater than anticipated. The producing differential (psi) will not U-tube to the next valve.

Distance in Feet Between Valves. One of the most controversial subjects in the gas lift field is the distance in feet between valves. This distance is governed completely by the maximum pressure differential (psi) which can be made to exist across each valve under actual operating conditions. The higher the PI of a well the lower the maximum operating differential (psi) will be across each successively lower valve. Thus, the higher the PI the closer the valves must be spaced together for the installation to perform as it should. In many cases the friction loss, or flowing gradient, in the tubing (psi) will approach that of the operating casing pressure (psi) relatively near the surface. When this condition is expected the spacing between the valves in the lower part of the string should not exceed 200 feet apart if full benefit of the casing pressure is to be utilized. With 200 foot spacing, a 100 (psi) producing differential will pick up the next valve in the string. (Refer Graphs C and D.)

Operating Pressure and Volume Requirements. (Refer Graph B.) Generally speaking, the following pressures are required for good gas lift practices.

Conditions
(a) For wells with PI's of .5 or less (up to 250 barrels daily).
(b) For wells with PI's of .5 or more (250 barrels or more, daily).

Quite a few of our ancestors in 1600 honestly believed that a race of chaps like this inhabited the unexplored west of the New World. Modern scholars believe, however, that this glamorous portrait may have been prophetic—a picture of a wildcatter of the future who stuck his neck out once too often.

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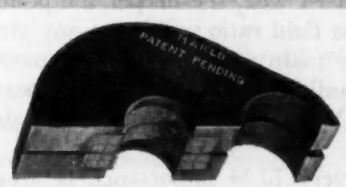

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Pressure Requirements

(a) 100 (psi) for each 1000 feet of depth not to exceed 700 (psi).
(b) 150 (psi) for each 1000 feet of depth not to exceed 1000 (psi). (Higher pressures can be put to use, but are normally not required.)

Actual pressure requirements can be determined (if pi data is available) by plotting gradient versus depth at the maximum rate desired. (Refer Graph C.) Volume requirements for average gas lift are as follows:

Constant flow gas lift . . . 150 cubic feet per each 1000 feet of lift.
Intermitting gas lift . . . 250 cubic feet per each 1000 feet of lift.
"Stop-cock" gas lift . . . 300 cubic feet per each 1000 feet of lift.

All volume figures are based on a wide range of many wells.

It must be stressed that the gas volume per barrel for each 1000 feet of lift is not a straight line function and allowance must be made. (Refer Graph B.) This graph shows volume in relation to depth for different types of gas lift.

Reservoir Decline. If it is anticipated that the reservoir will have a rapid decline, this factor must be considered in the installation design and additional valves run to take care of the lowering fluid level. (Refer Graph E.)

Use of Packers. The use of packers in gas lift work is, of course, governed by the type of installation. Whether or not a holddown packer is required will be governed by well conditions. Their use in relation to basic types of wells is considered below.

On the high bhp, high PI type of well, a packer is not necessary insofar as keeping pressure off the sand is concerned, as the flowing bottom hole pressure always will exceed the input gas pressure. However, it is recommended that a packer be used in this type of well to confine all production to the tubing string. Without a packer it is quite possible to produce up the casing and through the lower valves, causing abnormal wear on the gas lift valves and mandrels. This occurrence is not uncommon.

When running a packer in this type of well, effective reverse checks are of utmost importance. If the reverse checks leak, the packer may as well have been omitted from the installation since the well fluids can enter the casing annulus through leaking check valves. This is due to "backwash" from the tubing.

On wells with a low bhp that are to be produced by standard intermitting gas lift methods, a packer is essential to keep the well from blowing around bottom.

On wells produced by the "stop-cock" method, a packer is not re-

Common Misconceptions Regarding Gas Lift Installations

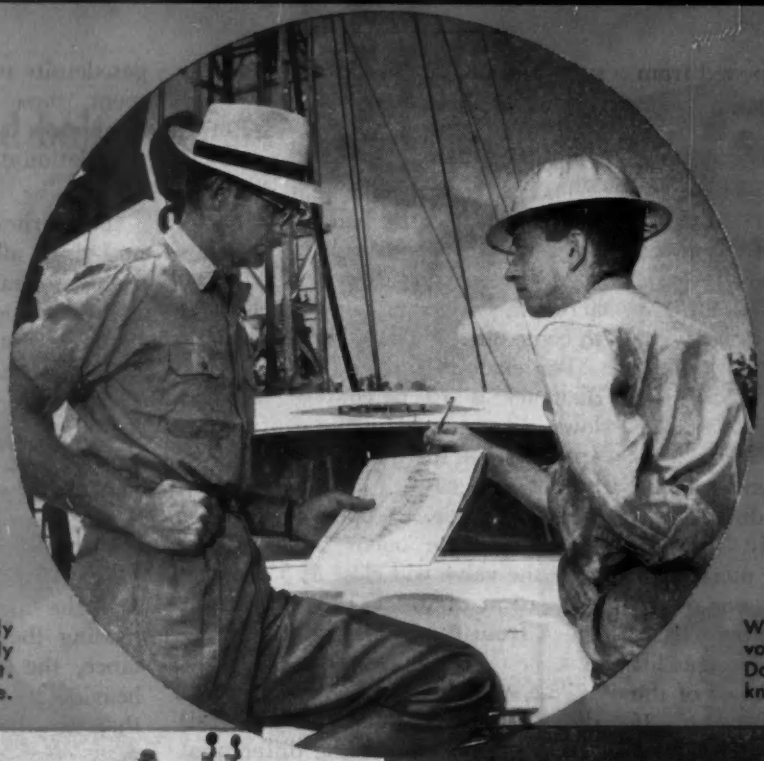
- There is a very general belief that the operating depth of a well may be determined by reading the casing pressure. Actually, in a vast majority of cases this belief is incorrect. Further, it is misleading in that it tends to make the operator believe that the well is lifting deeper than it is. Many wells, at present, are producing a limited volume of fluid simply because it has been assumed that the well is producing on bottom—this assumption being based on the operating casing pressure reading.

  It is suggested that the bottom hole pressure bomb be used to determine the depth of lift particularly on wells that do not make their calendar allowable.
- The practice of standardizing on one type of installation for all wells can lead to considerable production losses.
- Stepping the operating pressure down on each individual valve in the string is not necessary. On wells with good to high PI's, and on deep wells, this practice can be very detrimental. Many installations have been, and are being run with all valves set at the same pressure in order that higher operating pressure may be utilized at the bottom where it is needed most. The writer recommends running installations with all valves set at the same presssure.
- Normally, the spacing of valves is not associated with full utilization of the casing pressure. However, if the valves are spaced too far apart, a large percentage of the energy and pressure forces are dissipated in pressure drop across an upper valve. This is quite common.
- Another common belief is that the point of gas injecton is the depth of lift. This is true both in intermitting and "stop-cock" gas lift work. The deeper the point of gas injection, the greater the volume per barrel required. However, this is not true on high bph, high PI, constant flow wells and consequently is confusing to some.

  On a high PI well, the deeper the point of gas injection, the lower the input gas fluid ratio will be at any given rate of flow.

  This is the main reason that valve spacings should be close together on high pi wells so that full casing pressure may be put to actual use rather than being dissipated in pressure drop across one of the upper valves.
- In general very little importance is attached to the reverse check valve and mandrel lug design. Check valves of the double ball, gravity-acting type are much more superior to velocity or spring-loaded check valves. Back-wash through faulty check valves is the cause of many serious and expensive remedial work-overs and may be classified as one of the most severe problems of gas lift equipment.
- Lug design should be such that there is very little pressure drop between the bore of the lug and the inside of the tubing. This will assure longer mandrel life with less tendency toward corrosive action.
- There is a general misconception concerning the function of the productivity index. If the PI of a well is known, it will be dependable only for about 50 percent of the static pressure to determine the maximum possible rate of flow. If it is possible to draw a well down over 50 percent of the static pressure, critical flow will be reached, and very little, if any, additional fluid will be produced beyond the 50 percent drawdown figure.

  In some types of wells excessive drawdown actually can result in less fluid recovery.



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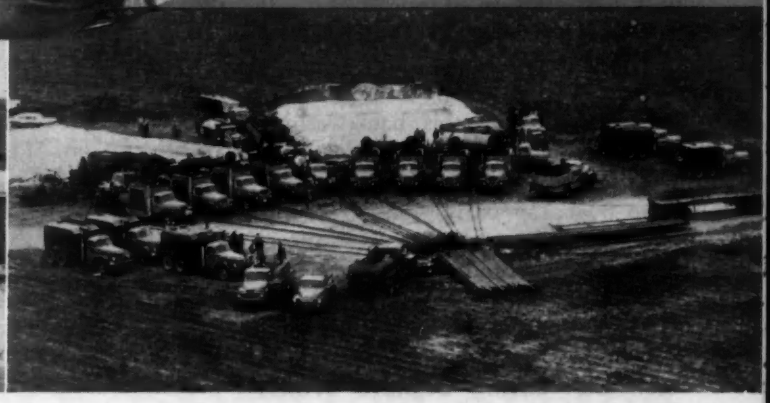

What's The Best Size Treatment For Your Well?

There is no stock answer to that question. One well may be an excellent subject for a huge high-injection-rate fracturing treatment using half-a-dozen Allison-powered pump trucks; another well might require a small gallonage job using only one diesel-powered pumper.

Each well has its own unique characteristics which require expert consideration before specific treatment recommendations are made—such factors as permeability, porosity, potential production and decline record. Dowell engineers are experienced in examining well data and recommending the most practical treatment indicated by the facts.

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quired and should be eliminated from the installation.

Dual or triple-completed wells usually require packers on all sands, and this is preferable, if possible. However, there are some types of dual installations where one sand is produced without the use of a packer.

Function of Reverse Check Valves. Although not commonly realized the reverse check valves is one of the most important parts of the gas lift valve assembly. This cannot be overemphasized when the equipment is being run in wells capable of producing over 150 barrels of fluid daily. In wells capable of these rates or more, it is common to be lifting from one of the upper valves in the installation. If so, the check valves on the lower gas lift valves must hold any tendency of the well to backwash through them. If the check valves fail to hold, damaged gas lift valves and mandrel will result. In many cases, holes have been cut in the casing by this back-washing action.

Remedial work in wells that produce over 150 barrels daily is being created by reverse check valve failures at a ratio of almost ten to one over that being caused by actual gas lift valve failure.

Will Gas-Lifting Deplete Wells? The answer to the above is a definite "yes." Every type of producing reservoir is being produced now by gas lift methods. It has been proven beyond doubt that, when properly installed, gas lift can be depended upon to deplete wells.

The bottom hole pressure bomb has proven conclusively that ample producing drawdowns can be obtained with gas lift equipment to fullfill production requirements.

There are some types of reservoirs that can be depleted only with gas lift.

The above statements do not intend to infer that gas lift should be used everywhere but past well data and cost records clearly indicate that if gas is available, even where it must be compressed for gas lift, it is a positive and inexpensive method of producing fluids from wells with reservoirs of many types.

Spread characteristics of pressure charged gas lift valves. The spread of gas lift valve is simply the difference (psi) between its opening pressure and its closing pressure under producing conditions.

Spread is the function of two things:

1) The ratio of the seat diameter of the valve to the bellows or piston diameter of the valve;

2) The pressure drop or differential across the valve at the time it is made to come open in the well.

For example, assume that the seat diameter is 10 percent of the bellows diameter, that the differential (psi) across the valve (between the tubing and casing) at the time the valve is made to open is 200 psi, that the valve opens at 550 psi—then the valve will close at 530 psi or, 10 percent of the 200 psi differential taken from the 550 psi opening pressure.

The spread of the valve will vary in direct relation to the differential (psi) across it. The higher the differential, the higher the spread. The change in spread is in the opening pressure; the closing pressure remains a constant—within reason. This is because the valve is in nearly perfect balance as it moves to its seat. It is unbalanced by the ratio of the seat area to the bellows area at the time of opening —thus the spread.

In intermitting gas lift work spread should be considered. The volume of the annulus into which gas is to be injected should be analyzed so that the spread of the intermitting gas lift valves would not be so great as to utilize more gas than actually is required because of excessive spread. Excessive spread means excessive volume. All gas lift manufacturers consider spread characteristics in their designs. Spread is critical only when the valve is being operated with too high a pressure drop across it. Ideal operating conditions should be 100 psi pressure drop or less, across the valve.

The spread of standard valves generally is satisfactory under almost all normal conditions. Special valves are built for special applications with regard to spread, however their use is at a very minimum.

Field testing does not reveal these spread characteristics due to lack of volume in the test rack assembly.

Effect of Temperature, Gas Density and Back-Pressure on Operation of Modern Gas Lift Valves. Although much may be written regarding the effect of temperature and gas density on modern gas lift equipment, these forces compensate for themselves to such an extent that few installation designs bother to use them at all.

The writer is in accord with this, and since all modern gas lift equipment is manufactured with these points considered, the "Graph System" of installation design does not take them into account to any extent. Entering them into the installation data would gain no really beneficial results.

It is, however, the effect of temperature and gas density, along with back pressure in the tubing, which makes it impossible to consistently read the operating depth of a well by reading the casing pressure. For intance, the gas density or gravity is heavier at the bottom of the casing than at the top. Temperature will vary considerably with the rate of flow. Even though two wells are producing from the same depth at the same rate of flow, the back pressure will not be identical in both wells. All this considered, plus the fact that there is always the possibility that one of the gas lift valves may be slightly off pressure, leads the writer to advocate the use of the bottom hole pressure bomb to establish the working depth of a well. The bomb certainly should be used to establish positive production data on trouble wells which are not producing their allowables.

Part 2 will appear in the September issue of WORLD OIL.

About the Author

E. D. McMURRY, president, McMurry Oil Tool Specialties, Inc., has had over twenty years of experience in product and installation design of gas lift and allied equipment, with supervisory work in most of the oil producing areas of the United States, Canada and Venezuela.

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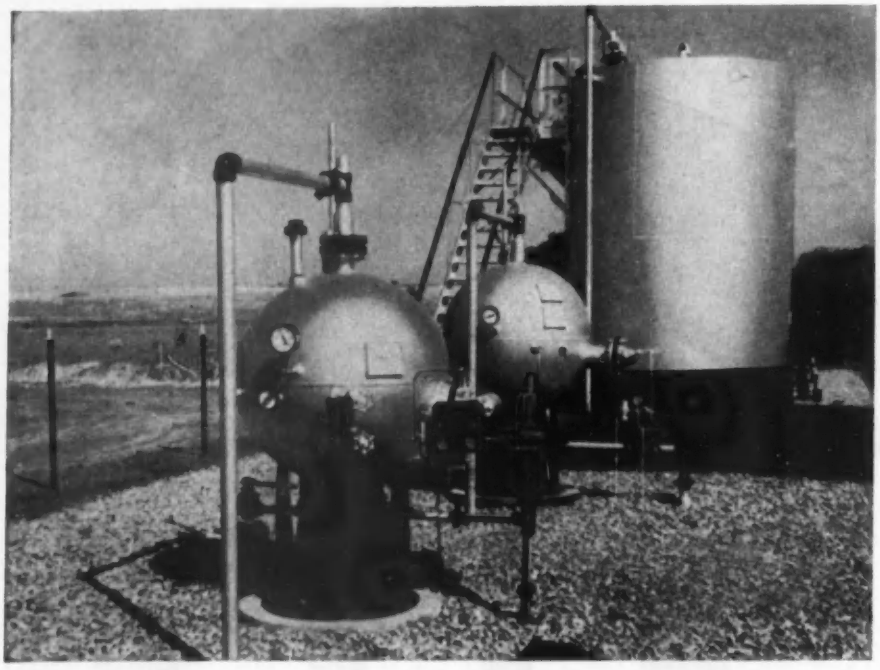


Tank battery and spherical separator installation. This installation incoroprates both high and low pressure spherical separation.

Part 2

Gravity Conservation: A Key To Increased Revenue

How important is the production equipment on your lease to gravity conservation? What part does each unit play in the program to make your operation more profitable? Are you using your equipment in the most effective manner possible? Here is a chance to find out.

By LAWTON L. LAURENCE and WALTER E. HUFFMAN
Black, Sivalls & Bryson, Inc.
Kansas City, Mo.

ANY ATTENTION OR consideration given to equipment on the lease between the wellhead and the storage tank is for the purpose of increasing the yield and gravity of the product. The basic equipment found on a lease usually consists of separators, heaters, emulsion treaters and free water knockouts. Any one or all of these may have an effect upon the ultimate quantity and gravity of the product stored.

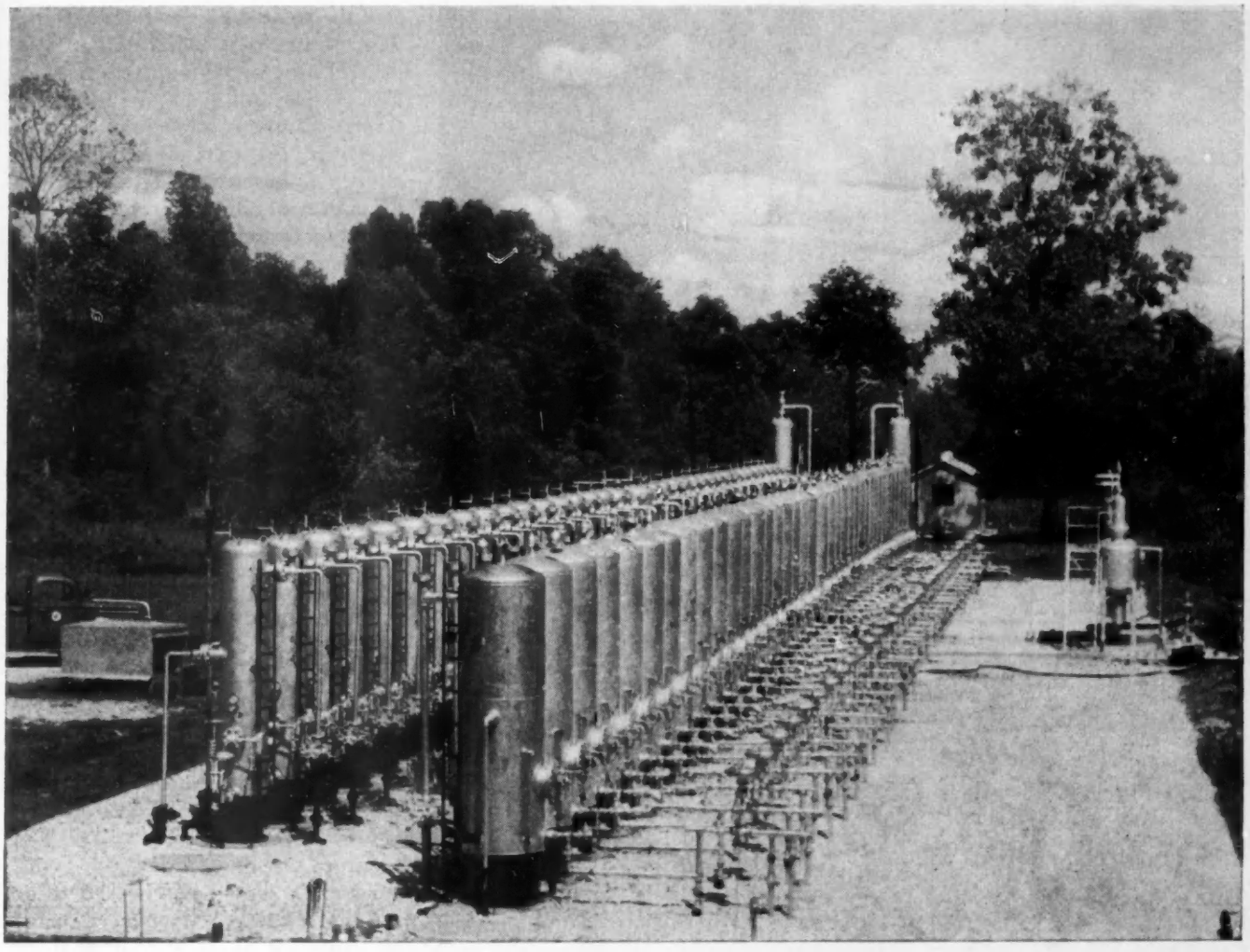
Separators. Where oil and gas separation is used on the lease, the quantity and gravity of the oil is directly dependent upon the separation temperature and pressure. For years now producers have used a process called stage separation to reduce wellhead pressure to a lower value where the products are easily handled with the highest liquid yield. It has been found that reduction of pressure in small increments increases the yield of hydrocarbon liquid. However, each reduction requires a separator, and, of course, the number of stages or reduction increments are limited by the economics of the installation. Experience with stage separation equipment has shown that for each number of stages there are optimum pressures for the intermediate stages through which the maximum yield and gravity are obtained. Through improper selection of pressures and temperatures, serious losses in gravity occur. Another point to remember also is that the lower the temperature of the separation stage, the higher will be the yield.

Reservoir conditions change with time, and this means the operator should periodically check his separation equipment to assure that he is operating at optimum conditions. Stage separation tests, examination of gas back pressure valves and relief valves for tightness of shut off and a check on wellstream temperatures are all measures available to the operator to determine his optimum conditions.

The procedure followed in conducting a stage separation test is to set the first separator stage at various values and calculate the intermediate stage pressures using Whitely's (1) formula. For each set of conditions the amount of stock tank liquid produced during a 24-hour period at this condition is plotted against the first separator stage pressure. Additional curves of specific gravity versus first separator pressure and gas-oil ratio versus first separator stage pressure are also valuable to the operator in making the final selection of his most favorable first stage pressure. The results of several stage separating tests indicate the optimum first stage pressure occurs where the gas oil ratio is the least and the API gravity of the stock tank liquid is the highest. This gives a further check on the "amount of stock tank liquid produced versus separator pressure curve," since the highest recovery will occur with the lowest gas-oil ratio and highest API gravity. Determination of the intermediate stage pressure can be made as follows:

Assume: First Separator Stage Pressure 300 psi
2 Separators and stock tank are to be used
Stock tank pressure 14.7 psia

(1) "Optimum Conditions for Con-



An example of stage separation using vertical separators. This central separation station accomplishes two stage separation with the high pressure stage on the left and low pressure stage on the right side of the photograph.

densate Recovery," Burton Whiteley, M. S. Thesis, University of Tulsa, 1947.

$$R = n\sqrt{\frac{Pi}{Ps}}$$

$$= 2\sqrt{\frac{300}{14.7}}$$

$$= 4.52$$

$$\frac{P_1}{P_2} = R$$

$$P_2 = \frac{P_1}{R} = \frac{300}{4.52} = 66.4 \text{ psia}$$

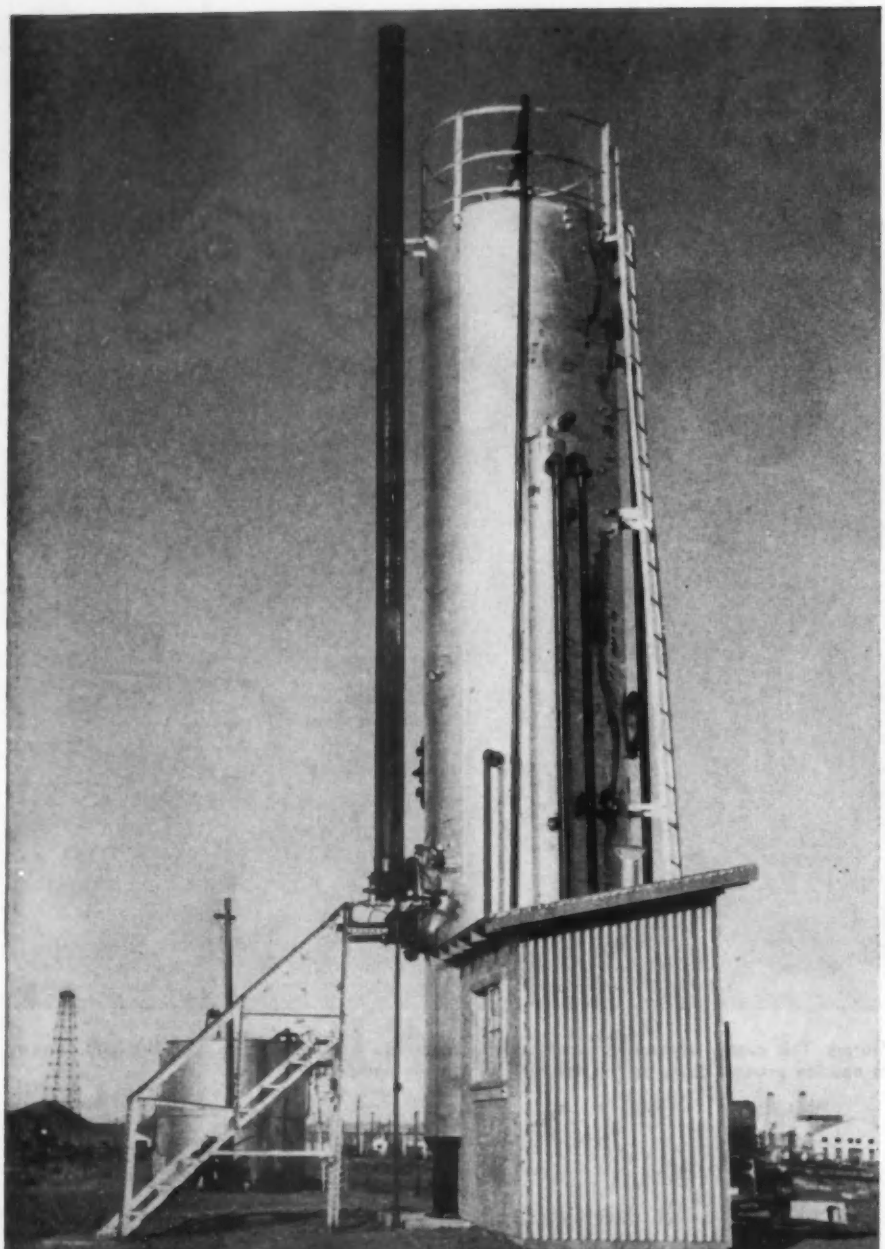
R = Stage Pressure Ratio
n = Number of separator stages used
P_1 = First Stage Pressure, psia
Ps = Stock tank or storage pressure, psia
P_2 = Second Separator Stage pressure, psia

Therefore, the stage pressures would be:

First Separator	300 psia
Second Separator	66.4 psia
Stock Tank	14.7 psia

Heaters. Heaters are primarily used around leases to heat the wellstream prior to choking (a pressure reduction) and separation. They are the principal means of controlling separation temperatures. In some locations heat is also necessary, during the winter season, to keep the wellstream flowing and above the hydrate temperature between the wellhead and production equipment. The wellstream temperature must be accurately controlled. If it is allowed to become too high, much of the recoverable fluid is driven into the vapor state and once vaporized, it is difficult to recover without being cooled down considerably. For this reason the separation temperature is carefully controlled. The stability of the produced fluids from a lease is directly dependent upon a constant separation temperature. Therefore, for good economical gravity conservation, there should be a thermostat or temperature controller installed either in the outlet of the heater flow coil or on the separator. This will control the heat input of the heater. The most common heater found on a lease is the water bath or indirect heater. With this unit the wellstream flows through a pipe coil immersed in a hot water bath. Controlling the temperature of this bath controls the rate of heat input to the wellstream.

Emulsion Treaters. When treating crude oil, it is usually necessary to heat the production in order to break the emulsion and settle out the water,



The water and oil discharge valves and all external controls are enclosed in a galvanized steel house near the base of this unique treater. Heat from the treater is utilized to maintain the controls and house above freeze-up temperature.

sand and sediment. The heating process naturally drives off some of the desirable hydrocarbons into the gaseous phase, and unless the process is carefully controlled, considerable loss in API gravity results. For this reason emulsion treaters that treat crude under pressure were developed. By maintaining pressure on the crude during the heating process, less of the hydrocarbons are driven off into the vapor space and lost. At the present time only the low gravity crudes are being treated in atmospheric type treating equipment and pressure type emulsion treater is universally accepted.

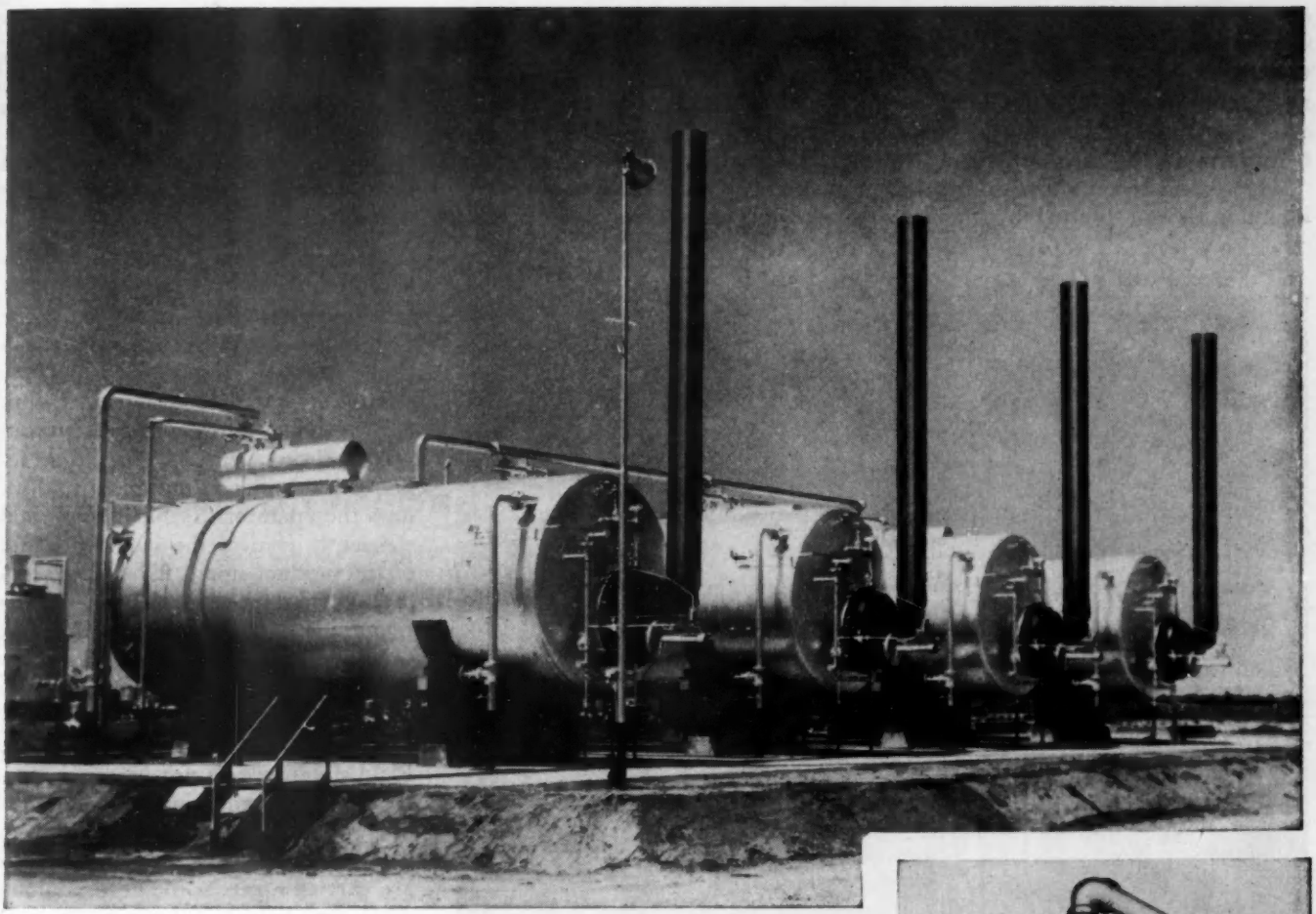
Manufacturers of emulsion treaters today are incorporating gravity conservation features into their equipment. Most treaters now have a gas and oil separation section where entrained vapor is quickly separated from the emulsion before treating. This cool gas is usually mixed with the hot vapors from the heating and settling section in order to condense the heavier fractions released during the heating process and recover these fractions in the treated crude. In addition to providing a method for condensing and recovering the heavier fractions released from the crude during the heating process, an external heat exchanger is usually provided to cool the treated oil down to a storage temperature that will result in very little, if any, vapor loss. This heat exchanger can utilize either the cool incoming emulsion or some of the vent gas from the separation equipment ahead of the treater. It makes little difference whether the treater is horizontal or vertical as they both usually incorporate the same features. The recent introduction of a steam heated emulsion treater in which the crude is heated directly with steam resulted in lowering the treating temperature required and this in turn reduced the amount of vapor released during the heating process.

Treaters should be examined to assure that the treating temperature is not set too high. The use of additional chemical or possibly a different chemical may allow the use of a lower treating temperature. The overhead gas should be checked by means of a drip in the line, to see if foaming or liquid carryover is occurring. This would indicate that the gas separation section is either too small for the problem or the gas from the heating section is not being cooled enough before leaving the treater. The temperature of the treated oil to the stock tank should be checked to determine if the heat exchanger surface is fouled or if additional heat exchanger should be added to eliminate flash losses at the stock tanks.

As a lease becomes older, more free water is usually produced with the crude. In some cases, the first evidence that a treater is being overloaded with water is a rise in the water temperature out of the treater. This indicates that water is being heated unnecessarily, thus reducing the amount of heat that can be utilized for treating the oil-water emulsion. When this condition exists, the addition of a free-water knockout ahead of the treater is required in order to remove the water before it enters the treater. This allows the treater to regain its treating capacity.

Free Water Knockouts. The purpose of a free water knockout is to remove the free water from the produced well stream before further processing. Free water is arbitrarily defined as that water which will settle out in five minutes.

A free water knockout is not designed to remove emulsified water. The application of heat and chemical agents are usually required to break



Horizontal treaters, 10 feet by 30 feet, utilizing the integral system generator for heating oil.

an emulsion and neither of these features are incorporated in a free water knockout.

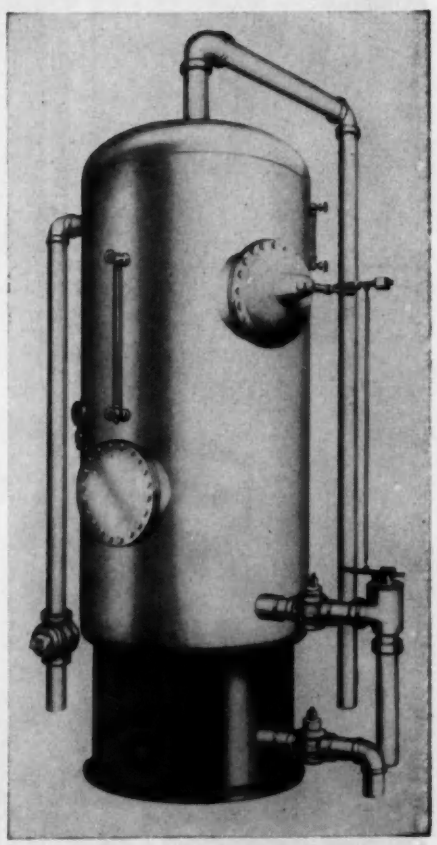
They are installed ahead of separation equipment on low temperature equipment to eliminate glycol losses and to prevent overloading the glycol regenerating equipment. On low pressure leases they are usually installed ahead of emulsion treaters in order to prevent reduction in treating capacity as explained in the previous section on treaters. The operating pressure of the free water knockout should be as high as possible in order to hold gas in solution. Relief valves and back pressure valves should be periodically checked for valve setting, excessive friction and tightness of shut off.

NEW GRAVITY CONSERVATION AIDS

Many leases now include specialized equipment such as low temperature separation units, stabilizers and small lease gasoline plants. All of this equipment is designed to increase the production of a lease and upgrade the gravity.

Low temperature separation equipment takes advantage of the natural expansion refrigeration available through pressure reduction to chill the wellstream and increase the liquid recovery. These units are designed for use on gas condensate type wells where considerable wellhead pressure is available and a moderate sales gas line pressure allows a pressure reduction of 500 psi or more. There are two basic types of low temperature separation units.

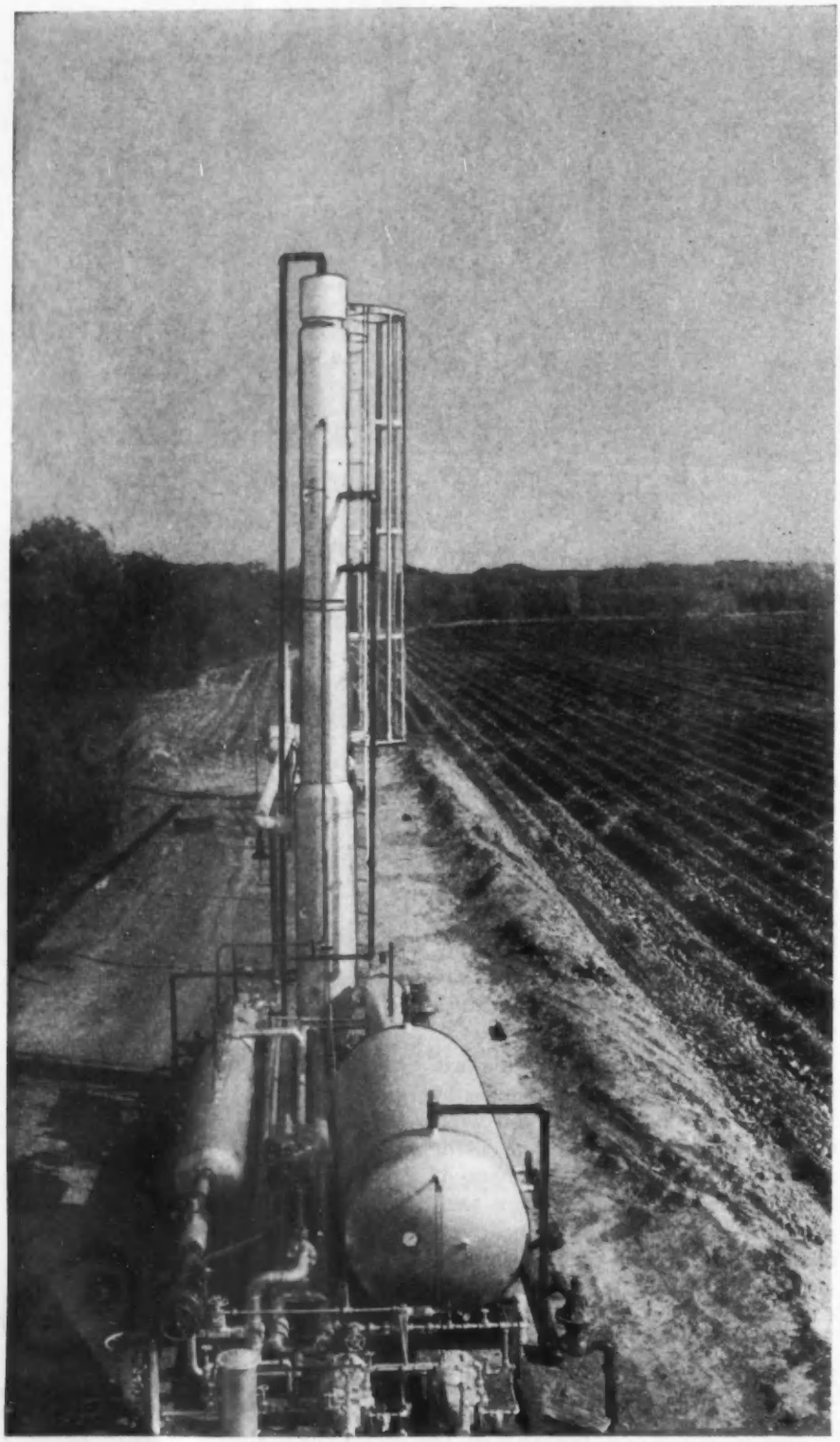
The first is a unit without hydrate inhibitor. Without a hydrate inhibitor it is only possible to cool the wellstream down to the hydrate point ahead of the choke. The cooling is accomplished by passing the low temperature separator gas in heat exchange with the wellstream. The API gravity of condensate produced from equipment of this type runs between 50 and 60 degrees API. This type of product requires storage other than atmospheric to prevent serious loss in gravity as it will have a vapor pressure ranging from 19 to 24 psi Reid. All welded type storage tanks with pressure-vacuum relief valves are rec-



The vertical free water knockout is usually installed ahead of treaters or stage separation systems in order to separate free water from the wellstream prior to any further processing. Use of this unit reduces heating requirements in the treating system by elimination of heating excessive amounts of free water which would separate without application of heat.

ommended. It is always advisable to stabilize a product of this nature and therefore most low temperature separation units have a "stabilizer" installed to process the separator liquid before it is placed into storage.

The second type unit, with hydrate inhibitor, is not limited by the hydrate temperature due to the action of the inhibitor in preventing the formation of hydrates. This type of unit is capable of separation temperatures ranging from 45 to —20° F. depending upon the wellhead temperature and pressure and the pressure drop available. The API gravity of product produced from this type of unit operating at such a low temperature, ranges from 55 to 80 degrees API. It is absolutely necessary with this type of unit to either use stage separation or stabilization equipment to further process this product before it is stored.



A low temperature separation unit utilizing glycol injection to prevent hydrate formation anywhere in the system and incorporating field stabilization for processing the high pressure distillates produced in the unit.

Field stabilizers have been widely accepted as the "sure fire" method of reducing gravity losses. Normally the low temperature condensate from these units will require two or three separation stages to produce a product capable of being stored without severe shrinkage. The stabilizer replaces this staging equipment and allows the operator to economically and efficiently control the vapor pressure of the product stored. Even stage separation fluid will weather due to the retention of some methane and ethane in solution. The separation and modification of product quality afforded by a stabilizer is actually equivalent to a large number of separators in series. Field stabilizers do not use an expensive external reflux system but make use of the cold separator liquid to condense the heavier fractions which are carried up from the bottom along with the lighter fractions. In this manner, some internal reflux is induced in the tower with the result that the stabilizer functions similar to an externally refluxed column. Results from actual field installations where stabilizers are installed to handle the liquid from the low temperature separator show increases in recoverable stable product ranging from 5 to 15 percent over that obtained previously by stage separation units.

The operator can vary the product produced in a stabilizer by changing the tower pressure and bottom temperature to take advantage of seasonal storage temperatures or a variable market. This great flexibility, inherent in the stabilizer, has been a strong factor in increasing its application to lease problems to maintain an upgraded production.

The lease operator today has a wide variety of equipment from which he may select an efficient, integrated and flexible lease process that will produce maximum revenue with maximum gravity conservation from wellhead to pipe line.

—The End

For successful "first-time" cementing use the combination of BAKER CASING CENTRALIZERS to ensure ample clearance for placing a uniform body of cement around the casing—and BAKER WALL SCRATCHERS to scratch away the mud cake so that the cement will bond better with the exposed formation.

YOU MUST HAVE "EFFECTIVE CENTERING FORCE"

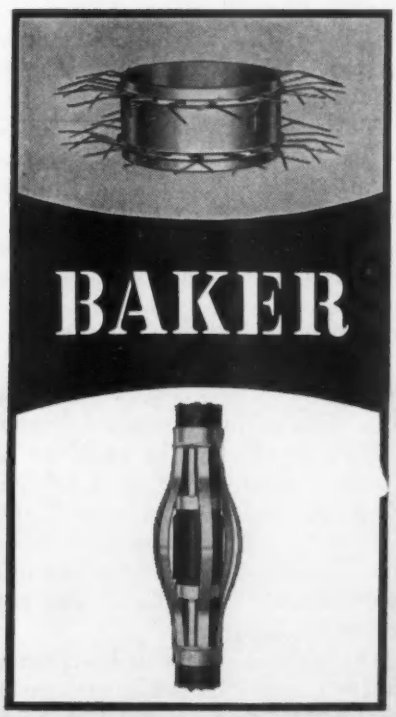
Baker Casing Centralizers have that *balanced combination* of proper spring *length* and proper *bowed height* ("reach") to provide Effective Centering Force *throughout the area to be cemented.* And, because each spring is pre-tested and pre-set in hydraulic presses, you have this Centering Force *at the cementing point,* regardless of depth or of "dog legs" in the hole.

YOU SCRATCH ONLY THE SECTIONS TO BE CEMENTED

Baker Wall Scratchers perform a "controlled" scratching job, because the wires remain close against the casing while running in the hole, and *do not damage the vital filter cake* built up on sections through which the scratchers pass. Only when the "wall scratching" operation is started, do the overlapping wires (positioned in a *double* shell) *really go to work* scratching away the mud sheath and exposing the formation for far better bonding of the cement.

OUTSTANDING COMBINATION

FOR BETTER PRIMARY CEMENTING



Baker Wall Scratchers also meet your specific needs because they are available with either 4½-inch long scratcher wires, or with 2½-inch long wires. You can also select either the HINGE-LOK Type which is hinged for easy mounting, or the SOLID RING Type which is *slipped over the casing.*

Contact the Baker representative in your area and get complete details about these Baker aids to better cementing. He has first-hand field knowledge that will prove valuable to you.

WALL SCRATCHERS

CASING CENTRALIZERS

You can choose Baker Casing Centralizers exactly suited to each cementing job because they are available with various bowed heights of the springs to meet different casing programs—and there is the Baker Model "H" HINGE-LOK Type which is hinged for easy mounting, or Baker Model "G" SOLID Type which is merely slipped over the casing.

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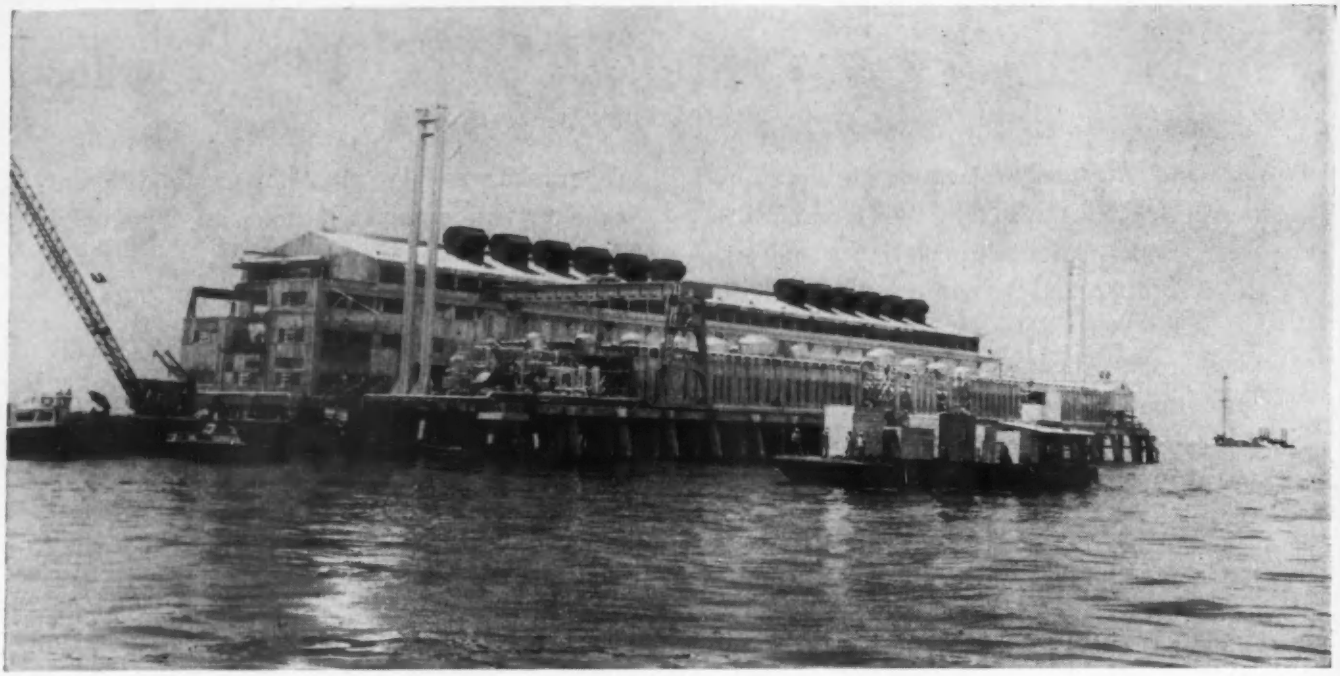

FIGURE 1—Conservation Plant Tia Juana 2, one of the largest of its type in the world. Plant went into test operation April 17, was inaugurated June 27.

Creole Builds Giant Turbine-Drive Gas Injection Plant

Creole's $28 million second conservation plant in Venezuela's Lake Maracaibo is seven miles offshore and is one of the largest installations of its kind in the world.

A SECOND GIANT gas injection plant, Tia Juana No. 2, has been completed by Creole Petroleum Corporation in Lake Maracaibo.

Located seven miles offshore from the Tia Juana area and six miles south of Plant No. 1, completed in September, 1954, the plant is a larger scale modification of the first project. The project is designed to inject 300 million cubic feet of gas daily into four reservoirs of the LL-453 area, more than twice the design injection rate of Plant No. 1. The first plant, designed to inject 137 million cubic feet of gas daily, has returned an average of 143 million cubic feet daily in two and one-half years of operation, with as much as 187 million cubic feet in a 24-hour period.

Objectives in the installation of both plants are:

- To increase the ultimate recovery of oil from Eocene reservoirs with pressure maintenance.
- To conserve gas until it can be used effectively at some future time.
- To permit lower operating costs through continued production of natural flow rather than by artificial lift.
- To increase the efficient rate of recovery of crude oil.

The new plant, Creole's seventh and largest, is the greatest achievement of the company's long range program for conservation, estimated to cost a total of $175 million by 1960. The program for the utilization or conservation of gas includes a third plant now in the planning stage with additional plants at Cumarebo, Mulata, Jusepin, San Joaquin (a system of three plants) and Quiriquire, and a liquefied petroleum gas plant being constructed at Ulé.

Greater Production Recovery Expected. The LL-453 area with four reservoirs, truncated Eocene monoclines bounded by a Miocene-Eocene unconformity, lateral faults and a down-dip oil-water contact, has a surface reservoir area of 9874 acres with maximum thickness of the section ranging up to 410 feet. Average net thickness of oil producing sands is 225 feet with a maximum range to 360 feet.

From discovery in April, 1945 to the end of 1956, the LL-453 area had produced approximately 270 million barrels of oil from an original estimate of 2⅓ billion barrels in place. Plant No. 2 is estimated to increase the ultimate recovery more than one-third of the amount recoverable without the boosting aid of injected gas. During the first two years of operation, injection into the LL-370 reservoir has resulted in an increased oil recovery amounting to 8,800,000 barrels in addition to recovery of 1,500,000 barrels of compression condensate. The injection has also conserved approximately 100 billion cubic feet of gas for future use.

The amount of gas to be returned to the reservoir is anticipated to be greater than that produced, to offset

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is the real villain in sucker rod pump troubles. It accounts for most of your repair and pump pulling expense.

The Martin Idea...

for getting away from this trouble has always been to make use of the best available materials — *Natural Rubber* for the key material in plunger rings; *Synthetic Rubber* for the key material in resilient ball guides for cages.

The accurately grooved and drilled metal body of **The Martin Plunger** does not touch the barrel. Only the resilient rubber and duck rings contact the barrel. This material — with its great natural resistance to abrasion as well as its slipperyness-when-wet — has a much slower wearing action on the barrel. Most often your barrel will not need replacing. These rings have an amazing ability to take the kind of abuse that goes with oil well pumping, and this means longer runs. Plunger cost is reduced because replacing the rings costs only about one fourth as much as a new plunger, and this saving is, of course, added to the barrel saving and longer runs.

Patent No. 2,591,174

The Martin Rubber Guide Cage protects the ball from all metal contact except when it rests upon its seat. The ball is protected to such an extent that ball and seat life is usually doubled. The synthetic ball guide and stop cannot beat out because of its resilience. Its life is therefore much greater than any metal and you get this longer cage life in addition to better ball and seat life. The two guides are easily replaced when the occasion does arise.

No real capital outlay is required to get these benefits because the cost of Martin Plungers and Martin Cages is very much the same as you are now spending for replacements — sometimes less.

All regular or stroke-thru ROD PUMPS and TUBING PUMPS can be equipped with Martin Plungers. Martin Rubber Guide Cages are made in all sizes and styles. Write for our catalog No. 4; also see Composite catalog for 1956-57.

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For more data on advertised products, use Readers' Service Cards, last page.

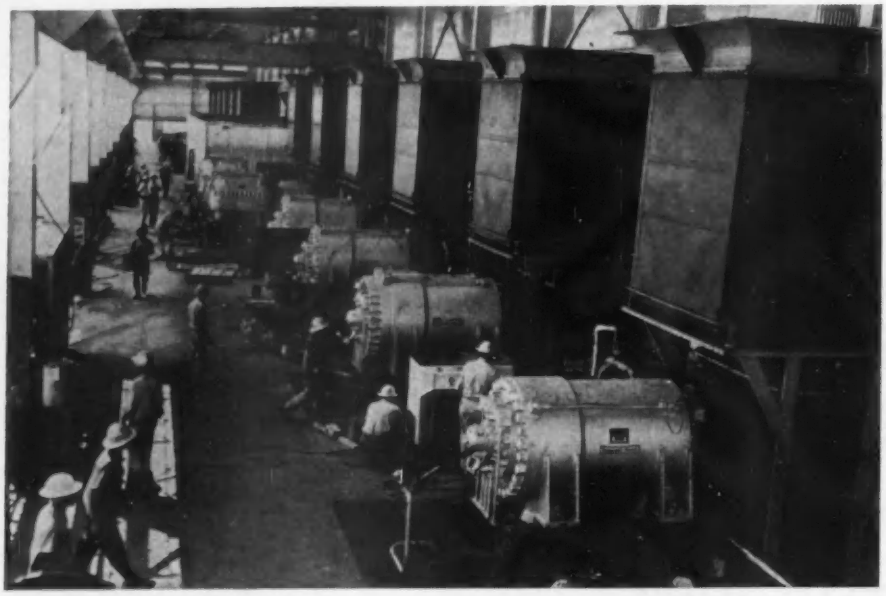

FIGURE 2—Half of the plant's 12 compressors are seen as finishing touches were put on their installation. The other six compressors are located beyond the control room which extends out from the middle of the compressor line.

the pressure decline that would normally take place. Gas is received from flow stations after oil and gas are separated and compressed for return through injection wells. Since gas production in the area is at low pressure, the gas gathering system inlet pressure to Plant No. 2 is 39 psig with an outlet pressure for injection of 1800 pounds per square inch gage as compared to 11-20 psig in Plant No. 1 with an outlet pressure of 1950 psig.

General Construction Plan Similar to Plant 1. Comparative statistics on conservations Plants 1 and 2 are shown in Table 1 with the general construction plan of Plant No. 2 very similar to that of the first project. With a framework of steel and corrugated aluminum used to sheath the framework, the turbines, centrifugal compressors, control room, machine shop, showers, change rooms and sanitary facilities are located on the upper floor of the building. Scrubbers, coolers and other equipment needed in the complex facilities of the plant are on the lower level. Four cranes are used in the new plant; one with a 40-ton capacity to handle turbines and compressors; one auxiliary 20-ton crane and two smaller cranes on the loading platform to handle materials aboard launches and barges.

Construction required approximately 15,000 tons of steel, an increase of approximately 6500 over the first plant. The plant is built on a platform 440 feet long and 131 feet wide, longer but more narrow than that of the first. Although size of the piling was larger on the second plant, it reduced the total number used for the foundation by 45.

Piles were driven into the lake bed for a platform in 85 feet of water, approximately 20 feet deeper than the Plant No. 1 area. Piles made of reinforced concrete are 200 feet long, tapered from 36 x 36 inches at the base in the lake bed to 24 x 24 inches at the top. A coordinated program for casting piles and slabs was necessary in order to eliminate a conflict with well operations in the lake. These piles as well as huge concrete slabs were cast and fabricated in Creole's yards at the La Salina industrial base.

Nine months after the inauguration of Plant No. 1, construction began on Plant No. 2 in September, 1955, with completion in April, 1957. A total of 25,000 cubic yards of concrete was necessary in the construction, 5700 more cubic yards than used in Plant No. 1. The two-story plant building covers an area of 23,208 square feet, 56 x 418 feet as against 75 x 305 feet in Plant No. 1.

Twelve gas turbines of 8000 horsepower each drive a like number of centrifugal compressors constituting the largest single concentration of gas combustion turbines in the world. Driving power of Plant No. 2 totals 96,000 hp, more than half again as much as that of Plant No. 1 which is 60,000 hp.

Turbine and compressor units are arranged in two six-stage compressor systems operating in parallel. At present a third plant with the same gas handling capacities as that of the second is in the early stages of design and is anticipated to be in operation

TABLE 1

Comparative Statistics—Conservation Plants Tia Juana 1 and 2

	PLANT 1	PLANT 2
Platform dimensions	143′ by 329′	131′ by 440′
Platform areas (square feet)	47,047	57,420
Water depth at plant site	62	85
Piles used for foundation	350	305
Size of piles	24″ by 24″	36″ by 36″ tapered to 24″ by 24″
Cubic yards of concrete used	19,300	25,000
Tons of steel used	8,530	15,000
Plant building dimensions	75′ by 305′	56′ by 418′
Plant building area (square feet)	22,875	23,408
Height of building	52 feet	60 feet
Gathering system (feet)	70,000	121,500
Injection system (feet)	40,900	29,100
Flow station supplying gas	11	12
Injection wells	5	4
Turbines and horsepower	10 of 6,000 hp each	12 of 8,000 hp each
Total plant horsepower	60,000	96,000
Centrifugal compressors	10	12
Number of compression stages	7	6
Gas compressed for injection	143,000,000 cfd	300,000,000 cfd
Gas compressed for fuel	17,000,000 cfd	28,500,000 cfd
Compression condensate	2,000 bpd	3,000 bpd
Inlet pressure	11–20 psig.	39 psig.
Outlet pressure	1,950 psig.	1,800 psig.
Construction began	February, 1953	September, 1955
Plant operation began	October 1, 1954	April 17, 1957
Project investment	$20,100,000	$28,000,000

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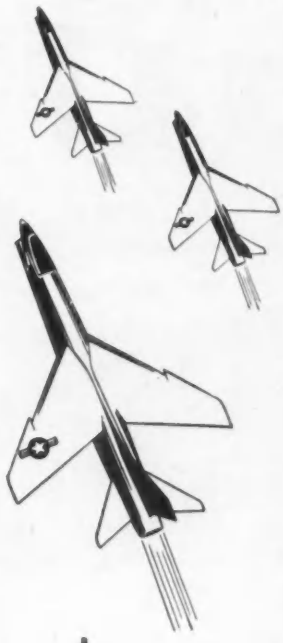

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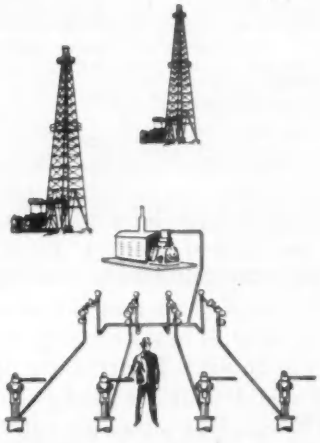

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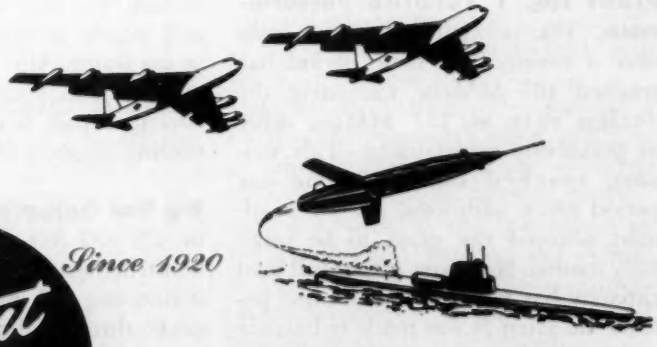

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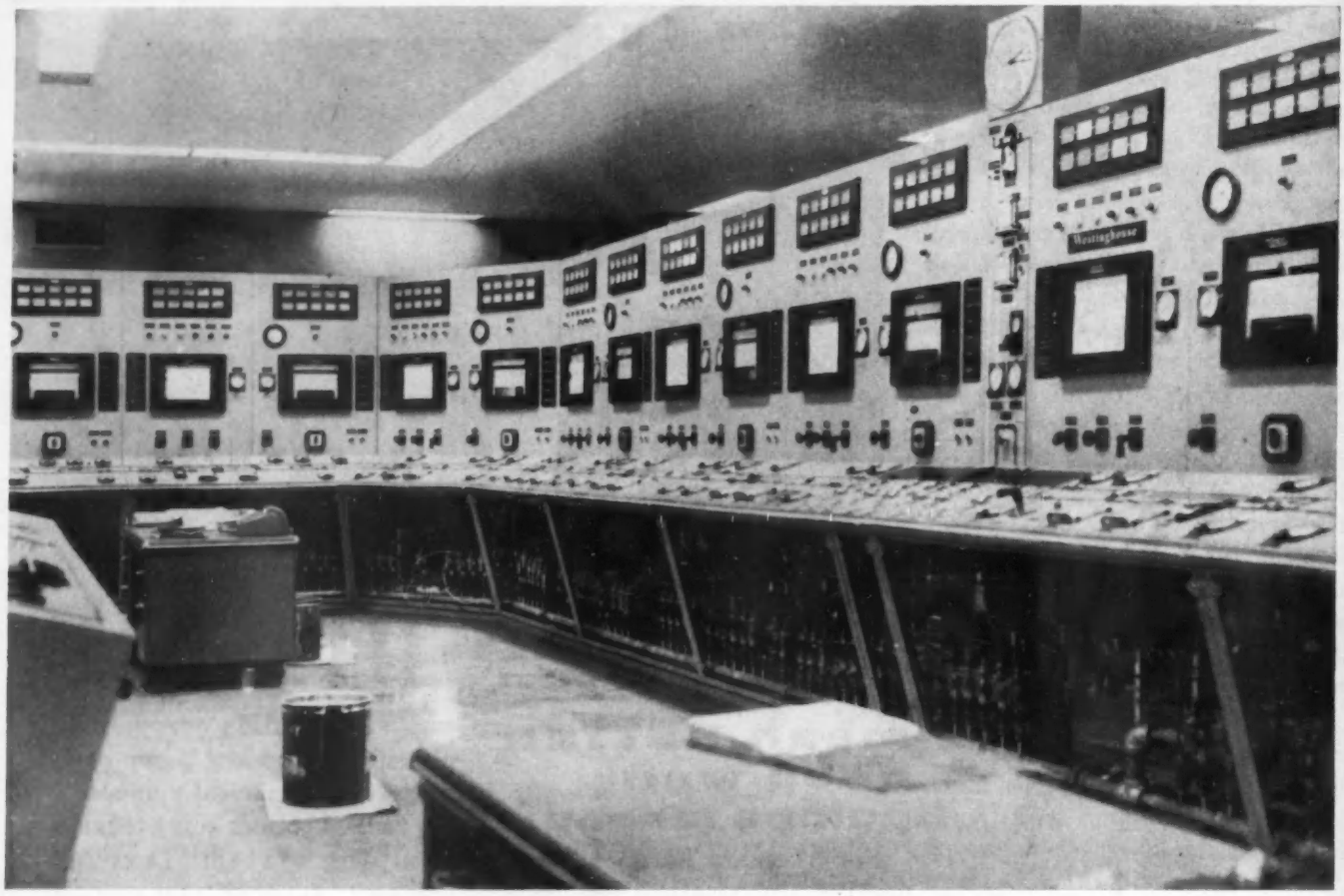


FIGURE 3—Graphic control panel is the "brain" which controls functioning of the plant. Continuous flow of gas through plant can be traced by operator on panels situated on shelf attached to control board.

by 1959 to service the TJ-102 area.

Plant No. 1 employed the use of ten simple-cycle, two-shaft gas turbines directly coupled to ten centrifugal compressors in seven stages of compression. These turbines, originally rated at 5300 hp, were later re-rated by the manufacturer at 6000 hp, at an ambient temperature of 80° F. These turbines and compressors are of similar design to the twelve 8000 hp operating the second plant, except the turbines are single shaft.

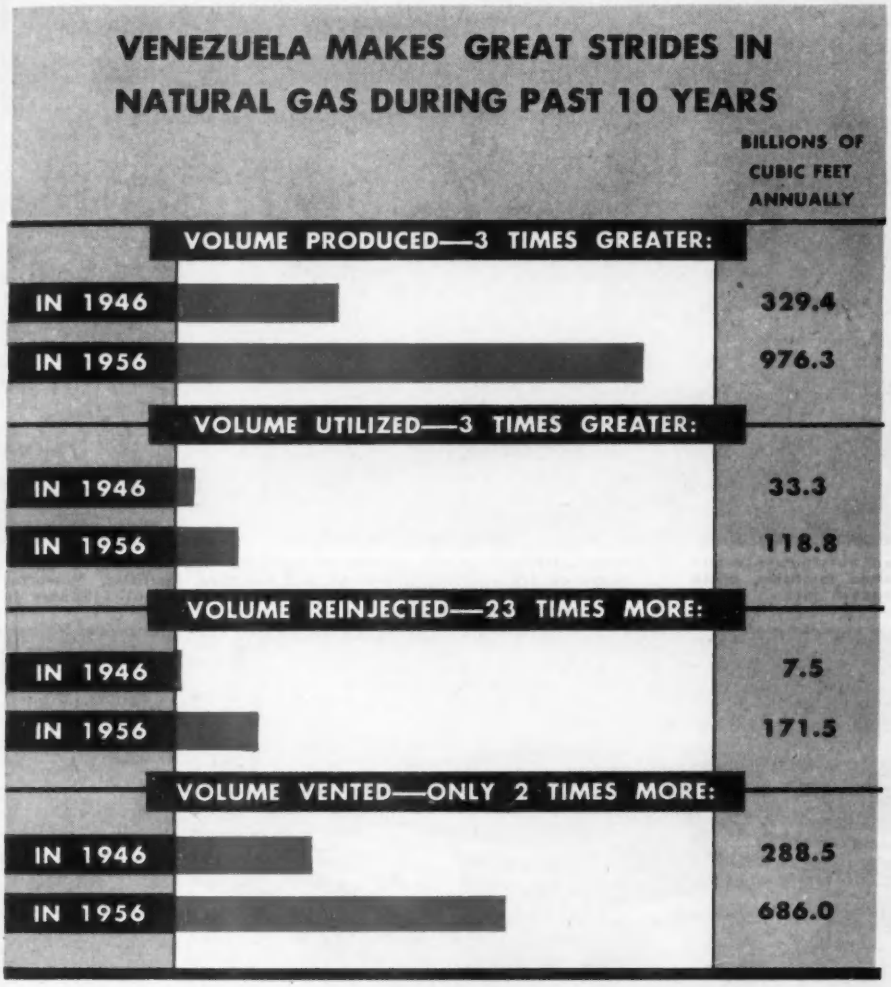
Plant No. 1 Turbine Performance. The maximum injection rate over a twenty-four hour period has reached 187 MMcfg, exceeding the design rate of 137 MMcfg daily as previously mentioned. This volume, reached during a four day period when additional gas was available, allowed the plant to be more fully loaded. However, actual full load capacity has not been determined because no attempt was made to balance turbine loads in this limited amount of time. Excluding downtime resulting from plant shutdowns, turbine availability has been 95 percent with the plant on stream 92.4 percent during the first two years of operation. The planned program for correcting excessive compressor hub vibration accounted for 38.7 percent of turbine downtime, 29 percent due to the first periodic inspection and overhaul of the turbine compressor units with the remaining 32.3 percent resulting from miscellaneous failure and corrosion maintenance and prevention.

The most serious operating problem encountered to date is corrosion, caused by use of lake water for cooling which is brackish (700-1000 ppm chlorides), highly oxygenated at the surface, virtually anaerobic at bottom and nearly as electrically conductive as sea water. After 22 months of operation, it was necessary to install new coolers, repair piping and modify the cooling water distribution system.

Big Gas Gathering System. A total of 121,500 feet of pipe was used in construction of the gathering system connecting 12 flow stations to the plant through three different sizes of pipe: 16, 24 and 30-inch diameter. The pressured gas from the plant to the four injection wells required the installation of 29,100 feet of 10-inch pipe. The launching and laying of pipe for the gathering system was carried out with some of the principles employed in developing the Plant No. 1 construction job. In weighting the gathering systems lines to overcome their natural buoyancy, an initial cast of asphalt was followed by a wrapping of fiber glass cloth and heavy mesh wire to which a heavy coating of concrete was applied. The concrete application was 4½ inches thick.

An integrated over-all gas gathering system has been studied and preliminary design work on the initial phase of this system is now underway to preserve the system of lake conservation plants and to meet future gas requirements in the Bolivar Coastal field area. Designed so that it may be expanded at a later date as needed until essentially all the gas produced in the area is gathered, this system for low pressure gas production requires a minimum pressure drop in the line. Lines as large as 40 inches in diameter will be needed to gather gas from outlying flow stations and maintain these small drops and special studies will be necessary to anticipate the problems encountered in handling, weighting and laying such large lines in water depths up to 100 feet.

—**The End**



Venezuela Conserves Its Gas And Increases Oil Recovery

Big growth in gas use. But of greater importance, gas injection capacity has risen from 17 million cfd in 1946 to 900 million in 1957.

By WARREN L. BAKER
Editorial Director, WORLD OIL

VENEZUELA IS making tremendous progress in the conservation and utilization of natural gas. Both the quantity utilized and the quantity conserved by reinjection into producing formations have increased sharply during the past ten years. However, far greater progress will be made in both phases during the next few years.

Venezuela's production of natural gas has increased sharply in recent years, growing along with its advance in crude oil production. The volume of natural gas produced in 1956 totaled 976⅓ billion cubic feet, three times more than the 329½ billion cubic feet produced in 1946.

Venezuela has had relatively little opportunity to utilize this increased gas production. It is located in a semi-tropical climate and has little need for heating fuel. Furthermore, it is not sufficiently industralized to require large quantities. Nevertheless, an increasing portion of Venezuela's production has either been utilized or conserved by reinjection.

The Venezuela Ministry of Mines and Hydrocarbons is just as interested in increasing the maximum recovery of oil as it is in the conservation of gas. Dr. A. Uribe, petroleum inspector of the Ministry of Mines and Hydrocarbons, in appearing before the Interstate Oil Compact Commission last December, estimated that present injection and water plants would result in the recovery of an additional 700 million barrels of oil in Venezuela.

Much Progress Last 10 Years. The volume utilized in 1956 was three times larger than in 1946, amounting to 12 percent of the quantity produced. However, to date the real story of natural gas in Venezuela is the extremely large growth in the quantity reinjected into producing formations. Twenty-three times more natural gas was returned to producing formations during 1956 than ten years ago. Reinjected gas represented 17.5 percent of 1956 production, compared with but 2.3 percent in 1946.

As a result a steadily decreasing portion of Venezuela's gas production is being vented to the air. Whereas 87.6 percent of the nation's production was vented to the atmosphere in 1946, only 70.3 percent was vented in 1956. This is a remarkable accomplishment in view of the tremendous increase in quantity produced.

More To Be Utilized. The quantity utilized (used as fuel or sold) totaled 118¾ billion cubic feet in 1956. This compared with only 33⅓ billion feet in 1946. It was almost double the

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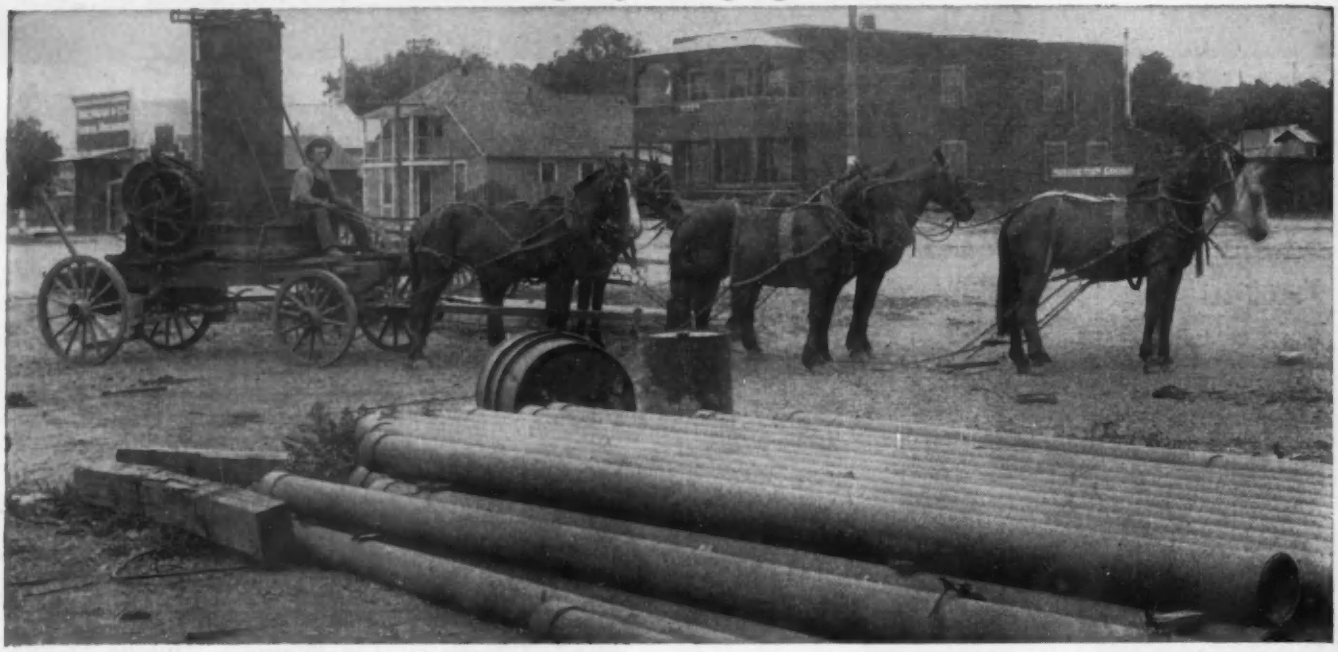

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(As of May 31, 1957)

GAS INJECTION AND RECYCLING PLANTS IN OPERATION

Year Started	Field	Plants in Operation	Current Effective Capacity (Cu. Ft. Daily)	Combined Capacity (Cu. Ft. Daily)
1932	Quiriquire	1	7,100,000	7,100,000
1933	Cumarebo	2	250,000	7,350,000
1946	Santa Barbara	3	10,100,000	17,450,000
1947	Jusepin	4	15,000,000	32,450,000
1948	Guara Ceste	5	18,600,000	.....
	Oficina	6	15,400,000	66,450,000
1949	Mulata	7	15,800,000	82,250,000
1950	San Rogue	8	70,000,000	152,250,000
1953	Chimire	9	31,000,000	.....
	Nipa	10	10,000,000	193,250,000
1954	Tia Juana	11	143,000,000	
	Mapiri	12	10,000,000	
	Chimire-R	13	3,750,000	
	Guario	14	8,000,000	
	Bella Vista	15	3,000,000	
	Saban	16	3,500,000	364,500,000
1955	Santa Ana	17	36,000,000	
	Boca	18	6,500,000	
	West Tarra	19	12,500,000	419,500,000
1956	San Joaquin	20	37,500,000	
	Oficina FM-4	21	1,700,000	
	Guario	22	8,850,000	
	Las Mercedes	23	1,650,000	
	Santa Rosa	24	107,050,000	
	El Toco	25	16,000,000	592,250,000
1957	Tia Juana	26	300,000,000	
	Trico	27	7,000,000	
	Mata Grande	28	4,000,000	903,250,000

WATERFLOOD PROJECTS IN OPERATION

Year Started	Field	Plants in Operation	Current Effective Capacity (Barrels Daily)	Combined Plant Capacity (Barrels Daily)
1948	Guara Oeste	1	3,000	3,000
1953	Taman	2	5,000	8,000
1954	Oficina	3	5,150	13,150
1955	Las Mercedes	4	1,650	14,800
1956	Trico	5	3,500	
	Soto Este	6	5,250	
	Nipa	7	2,600	26,150

GAS INJECTION PLANTS UNDER CONSTRUCTION, EXPERIMENTATION OR STUDY

FIELD	Capacity (Cu. Ft. Daily)	Remarks:
Tia Juana	250,000,000	Planned
Santa Rosa	100,000,000	Project Approved
El Toco	3,000,000	Under Construction
Chimire	15,000,000	Under Study
Mapiri	12,000,000	Under Study
Chimire-R	3,000,000	Project Approved
Mata	7,000,000	Under Construction
Tia Juana (Thermal Recovery)	.....	Projected
Mene Grande (air)	.....	Project Approved
Limon	375,000	Project Approved
Cabimas (air)	.....	Projected

WATER INJECTION PLANTS UNDER CONSTRUCTION, EXPERIMENTATION OR STUDY

FIELD	Barrels Daily	Remarks
Cabimas	2,000	Experimental
Cabimas	18,000	Experimental
Jusepin	4,700	Experimental
Qucupido	8,600	Under Construction
Cabimas	15,750	Experimental

volume utilized in 1952 and one-half larger than in 1954.

Gas utilized was 29.7 percent higher in 1956 than in 1955, and 1955 was 28.6 percent above 1954.

Most of the quantity utilized was used as fuel in the oil fields. Of Venezuela's 1956 total gas production, 7.45 percent was used as fuel, only 3.37 percent was sold, and 1.34 percent converted into natural gasoline plant products.

Far larger quantities of natural gas will be utilized in the future. To date, the only gas pipe lines supply the cities of Maracaibo, two residential areas in Caracas, Valencia, Barcelona and Puerte La Cruz. However, the government has announced plans to make gas available to other regions.

Under construction at the present time is a 26-inch 205-mile line from Anaco in eastern Venezuela. It will supply an electric generating plant at La Mariposa (near Caracas), all parts of Caracas, with a westward extension to Moron, Maracay and Valencia. Later, this line is expected to be extended to cities and towns located farther west.

The government recently completed the first stage of a petrochemical plant at Moron, near Puerto Cabello. The principal product for the time being will be agricultural fertilizer.

The government is studying additional plans for providing natural gas to other regions of the country.

Although Venezuela will never need large quantities of natural gas as a heating fuel, these plans will greatly increase the amount of gas used for residential and industrial purposes.

Big Reinjection Growth. The amount of natural gas returned to producing formations totaled 171½ billion cubic feet in 1956. This compared with only 33⅓ billion feet in 1946, and only 73.7 billion feet in 1954. Gas reinjected amounted to 17.5 percent of total production in 1956, compared with only 2.3 percent in 1946. Only 9.6 percent of the nation's production was returned to formations as recently as 1954.

At the beginning of 1946 there were only two old and small gas injection plants operating in Venezuela. By the end of 1950 there were eight plants in operation. This increased to 16 plants by the end of 1954, and to 25 by the end of 1956. As of May 31, 1957, three additional plants had

Continued on Page 150

Venezuela Natural Gas Production and Disposition

(All Figures in Millions of Cubic Feet Annually)

YEAR	Production	Utilized (Sold or Used as Fuel)	Reinjected into Formation	Vented	PERCENT OF PRODUCTION		
					Utilized	Reinjected	Vented
1946	329,444	33,336	7,557	288,551	10.12	2.29	87.59
1947	402,050	46,191	6,392	349,467	11.49	1.59	86.92
1948	472,148	61,658	12,960	397,530	13.06	2.74	84.20
1949	496,727	38,457	35,526	422,744	7.74	7.15	85.11
1950	557,114	39,445	42,024	475,645	7.08	7.54	85.38
1951	674,956	50,852	51,629	572,475	7.53	7.65	84.82
1952	740,429	61,835	62,188	616,406	8.35	8.40	83.25
1953	730,188	79,421	91,322	559,445	10.67	12.51	76.62
1954	764,018	82,667	73,700	607,651	10.82	9.65	79.53
1955	858,413	108,237	137,407	612,769	12.61	16.01	71.38
1956	976,326	118,796	171.485	686,045	12.16	17.57	70.27

Note: Gas used for gas lift included in vented gas figures since 1953. Previously such gas was included in reinjected gas.
Source: Venezuela Ministry of Mines and Hydrocarbons.

This Yacimientos Petroliferos Fiscales Bolivianos drilling rig is on a location which has been cleared out in the rugged terrain of the Camiri oil field.

Bolivia Oil Interest Warming Up - - Part 2

Bolivian Gulf Wildcat To Test YPFB Concession Acreage

This is the second of a two-part article evaluating the current status and prospects of the Bolivian oil industry, which is drawing renewed interest largely by the enactment of a new petroleum law. Part I, which appeared in the July issue of World Oil, discussed areas of interest and the new oil code. In Part II, the author discusses current drilling, exploration, production phases of the industry, in addition to the geology and export markets of Bolivia.

By ENRIQUE T. MAURI
Consulting Geologist
La Paz, Bolivia

Bolivian Gulf Oil Company planned to spud in an exploratory test in July on a tract within a 3 million-acre-plus concession reserved under the law to Yacimientos Petrolieferos Fiscales Bolivianos, the national oil company. This area is one of two covered by development agreements between YPFB and private companies.

Of the private companies currently active in Bolivia, only Bolivian Gulf actually had begun exploration operations. It has conducted aero-magnetometer and aerial photographic surveys, and was operating a contract gravity meter party.

Despite Bolivia's interesting petroleum possibilities, development to date has been relatively minor. Only recently has the industry attained the importance it deserves, thanks largely to the new oil law, discussed in the preceding installment.

Production. All Bolivian production has been from Devonian and Permo-Carboniferous sands, in anticlinal structures. No limestone or salt dome accumulations have been found. Table 1 shows the physical characteristics of the principal producing formations.

Initial production in all fields, except Sanandita, has been by natural flow during the first few years, followed by pumping. In the Sararenda sand, one of the best Camiri producing horizons, initial production per well varies between 500 barrels and 750 barrels per day, with a gas/oil ratio of 615 cubic feet per barrel.

Drilling. Since drilling activities of private companies prior to the creation of YPFB were largely exploratory, it has fallen to YPFB to develop the reservoirs discovered by both Standard Oil Company of Bolivia, which began operating in Bolivia in

TABLE 1

Principal Producing Horizons of Bolivian Oil Fields

FIELD	Number of Producing Horizons	Porosity (Percent)	Permeability	Total Thickness (Feet)
Bermejo	2	12	70 md.	92
Camiri	12	10	30	597
Guairuy	3	9	20	158
Sanandita	5	12	40	115
Toro	2	11	30–70	59

1920, and itself. YPFB currently has 11 rotary and two cable tool rigs in operation (See Table 3).

YPFB has continued to operate rigs at Buena Vista and Itapirenda, and plans to step up drilling activity on these structures shortly.

The cumulative crude production for Bolivia to Dec. 31, 1956, follows:

TABLE 2

Cumulative Bolivian Oil Production to Dec. 31, 1956

FIELD	Cumulative Production (In Barrels)
Bermejo-Toro	1,565,084
Camiri-Guairuy	11,140,609
Sanandita	2,035,513
Total	14,741,206

After conducting studies between 1920 and 1931 which led to drilling and the discovery of Bermejo, Camiri and Sanandita oil fields, Standard's concesions in 1937 were expropriated, and YPFB was set up with a complete monopoly of petroleum development. YPFB continued to develop the known fields, and it discovered the Guairuy field in 1947. YPFB reached its first production peak in 1949, with a daily average output of 1800 barrels.

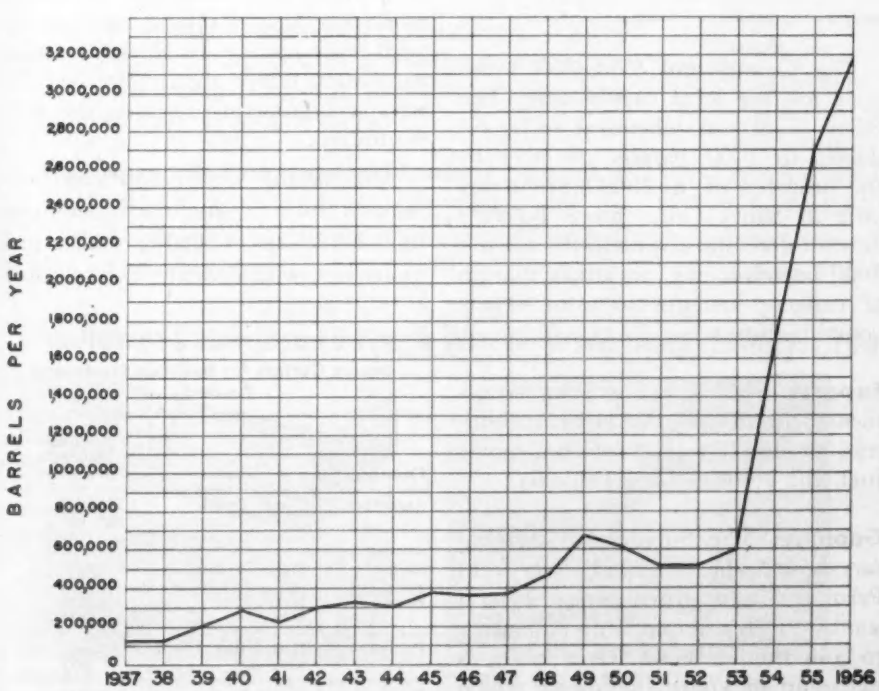
In 1952, the company was reorganized, and its exploration and drilling programs were expanded, with the resultant discovery of the Toro oil field and with increased production in Camiri, Guairuy and Bermejo. Total production for 1954 averaged 4400 barrels per day and rose to 8000 barrels a day in 1956.

Pipe Lines. Currently, Bolivia has a 765-mile pipe line network, extending

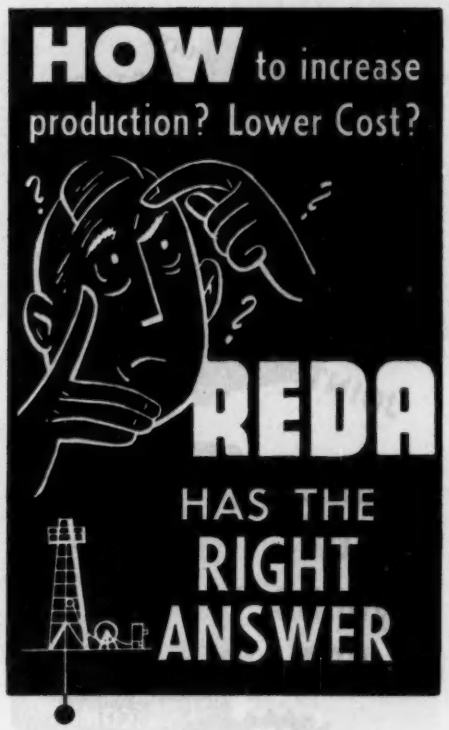
TABLE 3

Development Wells Drilled in Bolivia

FIELD	Total Wells Drilled	Number of Oil Producers	Depth Range (Feet)
Bermejo	24	17	1490–5000
Camiri	81	72	1480–6600
Guairuy	14	9	1740–5360
Los Monos	5	3	2900–4508
Sanandita	23	18	2020–4400
Toro	5	3	2980–4900
Total	152	122	.....



YPFB crude output rose more thna 6000 barrels daily in 1955-1956 period.



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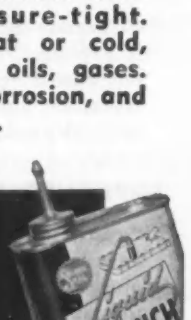

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TABLE 4
Pipe Lines of Bolivia

From	To	Length in Miles	Size in Inches	CAPACITY (Barrels Daily) Normal	Maximum	Status
Camiri	Cochabamba	331	6	8,000	12,000	Operating
Camiri	Yacuiba	159	6	4,000	18,000	Operating
Camiri	Santa Cruz	169	4	2,000	3,000	Under Construction
Cochabamba	La Paz	231	6	4,000	12,000	Operating
Lamboyo	Sucre*	44	4	3,000	5,000	Operating
Sicasica	Arica	229	8–10	....	50,000	Under Study
Sicasica	Ilo	243	..	....	.....	Proposed
Villamontes	Paraguay†	63	4	2,000	5,000	Proposed
Yacuiba	Bermejo	77	4	4,000	5,000	Proposed
Total‡		1,546	..	27,000	110,000	.....

* Branch of the Camiri-Cochabamba pipe line.
† At Paraguayan frontier this line will connect with a Paraguayan pipe line to Asuncion.
‡ Includes totals for pipe lines in each status, where data available.

from the Argentina border to the city of La Paz. Additional lines are under construction or study (See Table 4). The pipe line system doubtlessly will tie in with the proposed Argentine system linking the Madrejones and Campo Duran fields, near the Bolivian border, with the San Lorenzo refinery about 250 miles northwest of Buenos Aires.

Refining. YPFB's refineries now have a combined crude throughput capacity of about 12,000 barrels per day (See Table 5).

TABLE 5
Throughput Capacity of Bolivian Refineries

LOCATION	Throughput Capacity (Barrels Daily)
Cochabamba	6,000
Sucre	4,000
Camiri	1,450
Sanandita	410
Total	11,960

The Camiri and Sanandita refineries are for local supply only. The Sucre plant was scheduled to be reduced to 1000 barrels per day by the transfer of a 3000-barrel-a-day unit to Santa Cruz. Since Bolivia's current domestic requirements are but 7000 barrels a day, an ample margin of capacity remains to meet export commitments.

Exports. Bolivia has existing agreements with five South American countries to supply crude, fuel oil, motor fuel, and kerosine (See Table 6).

Geology. The Subandean sedimentary basin, which enters Bolivia from Peru and continues across it in a southwesterly direction into Argentina to join the La Plata River basin, is made up of known sediments which range from the Ordovician through the Gotlandian, Devonian, Permo-Carboniferous, Cretaceous, and Tertiary to the Quaternary. Although Cambrian and Pre-Cambrian sediments exist—and outcrop in not too distant areas—they do not reach the surface nor have they been identified in the Subandean region.

The Pre-Cambrian, which outcrops in the Brazilian Shield and in Northeast Argentina, is made up of gneiss and metamorphosed slates in its lower portion and of metamorphic schists and quartzites in the upper part. These groups may be Archean and Algonquin, respectively, which have been intruded occasionally by crystalline acidic magmatic rocks of the granite type. The section is several thousand feet in thickness.

The Cambrian, composed of quartzites and shaly schists, outcrops in Northwest Argentina. Its age has not been definitely established by fossils, and consequently should be accepted with some reserve. Its thickness varies somewhat, but is about 1300 feet. Its basal conglomerate rests on the Pre-Cambrian.

The marine Ordovician and Gotlandian form a single sedimentation unit made up of shales, schists and quartzites, with delicate intercalations

TABLE 6
Export Outlets for Bolivian Crude and Products

Country	Type	Amount (Barrels per Year)
Argentina	Camiri Crude	1,360,000
	Bermejo Crude	450,000
	Sanandita Fuel Oil	5,000 (tons)
Chile	Motor Fuel	120,000
Brazil	Motor Fuel	152,000
	Kerosine	15,900
Paraguay	Motor Fuel	2,560
	Kerosine	500
Peru	Motor Fuel	122,000

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of glacial sediments in some localities. The total thickness is unknown, but should reach several thousand feet.

The Devonian, of marine origin and considered to be the source of Bolivian petroleum, is made of grey to grey-black shales. Its uppermost part has numerous intercalations of sandstones which form the producing horizons in some Bolivian and North Argentine oil fields. This portion is of middle Devonian age, with a maximum thickness of about 2300 feet, and is known locally as the Iquiri formation.

Its top is an eroded unconformity, and the Upper Devonian is absent, so far as is yet known. The lower portion is composed entirely of shales, with a maximum thickness of about 9000 feet. Of Eo-Devonian age and locally called the Los Monos, it rests conformably on the underlying Gotlandian.

The Permo-Carboniferous contains four continental formations which are largely of glacial origin. The lower group, called the Tupambi, is formed of sandstones totaling as much as 1500 feet in thickness which constitutes the producing horizon of the important Madrejones and Campo Duran oil fields of Northern Argentina, as well as of some Bolivian fields. The Permo-Carboniferous, or Gondwana series, has a maximum total thickness of 5400 feet. Its age has not yet been definitely established.

The Cretaceous is made up of sandstone groups, thin limestones and marls, all of continental origin. In southeastern Bolivia, its thickness approximates 1200 fet. It rests uncomfortably on the permo-Carboniferous, and has an important unconformity in the upper half of the section.

The Tertiary unconformably overlies the Cretaceous, and its continental sediments can total a thickness of as much as 9000 feet.

Tectonics. A series of important west-dipping longitudinal faults form the principal tectonic characteristic of the Subandean ranges. These thrusts were produced by powerful west-to-east thrusts which created anticlinal lines coinciding approximately with the crests of the ranges, are separated by lines of synclines corresponding to the longitudinal intermontane valleys.

Throughout the length of these anticlinal lines are found numerous structural highs separated by saddles, and in these highs are located the known Bolivian oil fields. These anticlines, which have their axes inclined to the west, are sometimes affected by secondary faults, also longitudinal, inclined to the east, and located usually between the surface and the major faults.

Surface Oil and Gas Indications. In Bolivian territory, there are some 200 known natural seeps of oil and gas, the great majority of which are located along the Subandean belt. In general, these seeps come from the Devonian, although some are found associated with faults and fractures in more recent sediments. Nowhere in Bolivia is petroleum known to occur in rocks of pre-Devonian age.

—The End

Mexico May Up Oil Prices to Help Pemex

One hundred million dollars in additional income is required by Petroleos Mexicanos, Mexico's government oil agency, and prices of petroleum products might be raised across the board in order to obtain it, unofficial sources in Mexico have reported.

Within a few hours of the publication in Washington, D. C., of a report that Petroleos Mexicanos was seeking a sizable U. S. government loan, the daily newspaper Novedades indicated that the company had submitted to its board of directors for approval a new schedule of prices. The directors, who are officials of various branches of government named to administer the oil industry, have rejected similar proposals in the past, in what they regarded as the best interest of the public.

Although Novedades disclosed no details of the proposed new prices, it was suggested that percentage increases would be small and that the Mexican public "still would be getting the lowest-priced petroleum products in the world."

The industry's highly-publicized financial problems caused the National Chamber of Mines recently to describe the prices of its products as "unrealistic and uneconomic." The chamber also commented on the fact that the company had maintained subsidized prices for taxis, trucking and bus lines, and government departments.

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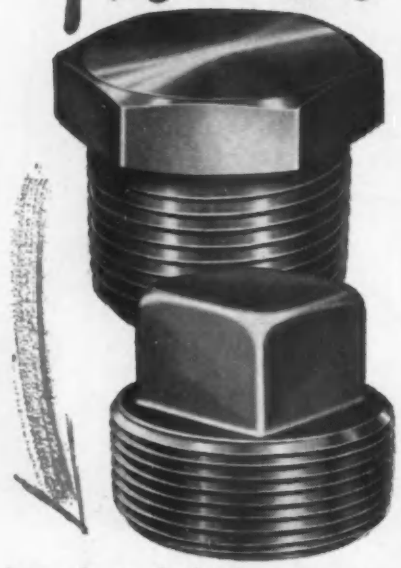

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Venezuela Conserves Its Gas

Continued from Page 141

been completed to increase the number of operating plants to 28.

1957 Will See Big Gain. A very sharp growth in volume returned to producing formations will occur during 1957. At the end of 1956 the effective injection capactiy of the 25 operating plants was close to 600 million cubic feet daily. Completion of three additional plants by May 31, 1957, had boosted the effective injection capacity to 900 million cubic feet daily, or 50 percent above the end of 1956.

Included in the three plants completed so far in 1957 was the largest outside the U. S. This is Creole Petroleum Company's Tia Juana #2 plant with a capacity of 300 million cubic feet daily (See WORLD OIL, August 1, 1957, issue).

Several other projects are under construction or in the study stage that will add to the country's ability to conserve natural gas. Among these are plans for a third plant at Tia Juana which is scheduled to have a capacity of 250 million cubic feet daily.

Government Discourages Waste. The Venezuelan Government has actively discouraged the waste of natural gas, and at the same time has actively urged the reinjection of natural gas into producing formations as a means of achieving maximum oil recovery while at the same time preventing natural gas waste.

The Government's official conservation policy is expressed as follows:

"The fundamental importance of petroleum to modern society presupposes maximum recovery and prevention of physical waste of natural gas and oil as prime and essential goals in the exploitation of the oil and gas fields of Venezuela. The requirement of methods and practices of development and operation of oil and gas fields which will achieve maximum recovery and prevention of waste of natural gas and oil is in the public interest; and the application of such methods and practices is mandatory upon those charged with governmental and industrial responsibility.

"In the system of free enterprise, the aspiration of business to earn legitimate profits is recognized. However, the mandate of maximum recovery and prevention of waste in the exploitation of irreplaceable natural resources, requires and renders obligatory the utilization of any auxiliary method or process which increases the former and prevents the latter, even to the extent that no profit with respect to the specific method or process is realized, as long as the production operation as a whole is profitable. In other words, the application of such methods and practices as fluid injection, water flooding, repressuring, underground storage of gas for future utilization and recovery of useful products from natural gas, is not only amply justified, but it is even mandatory within the framework of our Law of Hydrocarbons, and by reason of public utility and national interest."

Water Floods Also In Use. Recent years have seen the use of water floods as another means of increasing maximum recovery.

The first water-flood plant started operating 1948, and the second in 1953. During 1956 three water-flood projects were started, raising to seven the number operating in Venezuela.

At present one additional water-flood plant is under construction, and four others are in the experimental stage. —The End

Trailer-Mounted Rig Completes Long Journey

A trailer-mounted rig owned by Oil Drilling and Exploration Ltd., is being used for drilling in Western Australia, after a road haul of approximately 4000 miles, believed to be the longest ever undertaken with this type of equipment. The convoy included four vehicles, one carrying the draw works, another the folding mast, the third the structure and the fourth miscellaneous equipment.

The trip, which took approximately three weeks, began at Brisbane and continued through Sydney, Melbourne, Adelaide, Merridan, Mullewa and Geraldton to Shark Bay. Perth was by-passed because of limitations of some of the bridges in that area. From Shark Bay the equipment was ferried to Dirk Hartog Island, where it is being used for contract drilling.

When drilling in 130-degree temperature . . .

Air Condition Your Rig

This large land rig, built for operations in North Africa, is believed to be the first rig ever to attempt rig air conditioning.

By JOHN N. SCHUELKE
WORLD OIL Staff

FIGURE 1—The completely enclosed engine shed and the walled-in drilling floor contain about 20,000 cubic feet that will be air conditioned with six 5500 cfm evaporative type coolers. The coolers mounted in the windows or openings should lower the 130-degree temperature to a working temperature of 80 degrees.

ROUGHNECKING, a hot job in almost any climate would be unbearable in the 130° temperatures of the North African desert. To permit drilling in this climate and to provide round-the-clock working temperatures for drilling crews, Camdrill International, Incorporated, has taken delivery of what is believed to be the first air conditioned drilling rig ever to be assembled. This large drilling rig with a totally enclosed engine room and with siding around the drilling floor (Figure 1) will be equipped with six 550 cfm evaporative type coolers. They are expected to lower the 130° temperature to approximately 80° on the rig floor.

This large rig capable of drilling to 12,500 to 15,000 foot depths has a 143 foot mast and a drawworks rated at 1100 hp input. Power for this rig is supplied by four 12-cylinder diesel engines rated at the maximum of 600 brake horsepower each. The rotary table is independently driven by a 4-cylinder diesel engine.

The mud system on this rig includes two 18-inch duplex power pumps. These pumps are powered by in-line drive from the four-unit, swinging compound. They are positioned at the mud tanks so that they have a short, flooded suction with their discharge lines manifolded between pumps for ease of operation and flexibility in switching from one pump to another or for compounding the pumps. Prefabricated matting, of steel covered wooden framework, will be transported with the rig and used as a base matting for the pumps and manifolding.

Because of the extreme temperatures under which this rig will be operating a cooling tower has been provided on the heat exchanger equipment that cools torque converter fluid, hydromatic fluid and the drawworks brake fluid (Figure 2). This arrangement has been made quite flexible to meet maximum requirements of these various parts of equipment during their maximum operating cycle.

Another unique feature of this rig is the 270-barrel diesel fuel tank that is built to the rectangular dimensions of the electrical generating shed (Figures 3 and 4). This tank can be transported separately and when on location it can be hoisted and set on top of the electric generator house. In this elevated position it provides a suction head for the various diesel engines. In open country where surfaces are fairly flat this tank can be transported atop the engine shed in one load. On long moves, or in rough terrain the tank can be dismounted and moved as a separate unit. Built-in ladders, both on the engine shed and on the tank, provide ready access to the top of the tank for refueling or inspection.

The working structure of the rig that will be air conditioned has sidings made of angle iron with sheet steel painted with aluminum paint. These light weight sidings are prefabricated and are readily installed on location. Although not noted in the construction photograph in this article (Figure 1) the six evaporative coolers will be mounted in the various windows, both around the rig floor and the engine shed. Approximately 20,000 cubic feet of space, 10,000 cf in the engine house and 10,000 cf on the rig floor will be served by these coolers. This means

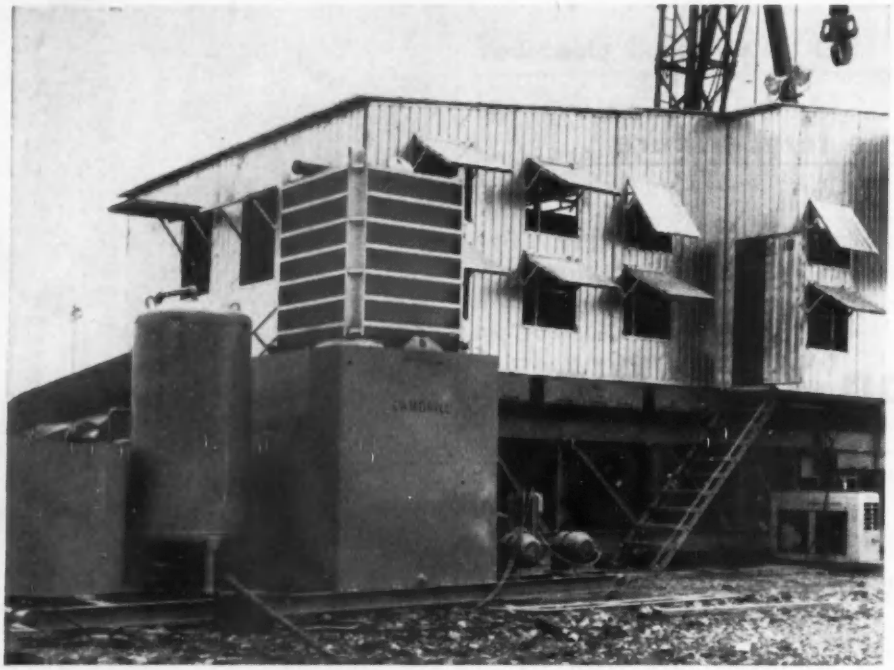
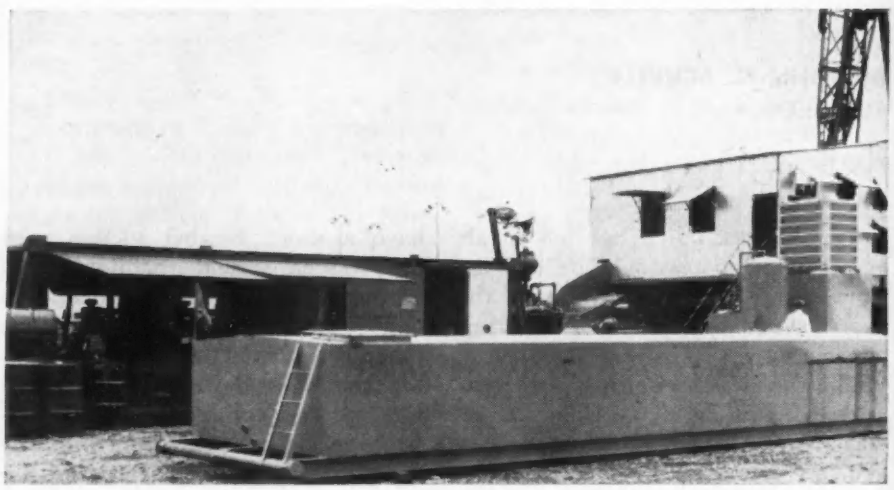
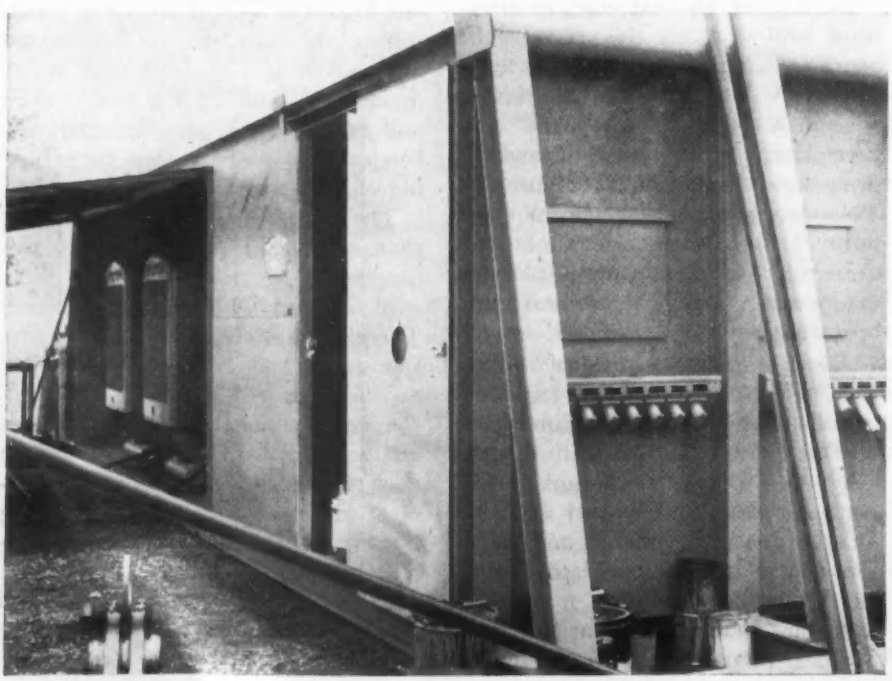


FIGURE 2 (above)—Skid-mounted heat exchanger equipment is shown here during assembly. This heat exchanger will cool water for the brake drums and hydromatic and will also cool torque converter fluid.



FIGURES 3 and 4 (right and below)—These two views show the auxiliary electric generating shed and tool shed unitized and mounted on single skid. Note convenient mounting of electrical outlets, all marked for proper line. The 270-barrel diesel fuel tank can be transported to provide a better suction head for engine fuel pumps. This also takes less space at location. Tank can be moved in this position on short moves in open country.



a complete change of air will occur approximately every 30 seconds. This rig which is believed to be the first rig ever to attempt air conditioning will be put to work for Mobil Oil Company of Canada, Limited, in Africa.

Because of the increasing drilling activity in places like the Middle East, North Africa, Central and South America, this air conditioned rig seems to indicate an important move in the direction of providing better working conditions and greater comfort for drilling crews. Living quarters on offshore rigs in the Gulf of Mexico have been air conditioned for some time with refrigerant type air conditioning. Because of the dry climate, the evaporative type cooler should work very satisfactorily in this North African venture. In North Africa where the climate is extremely high and the the humidity is quite low for the greater part of the year evaporative coolers should work very satisfactorily. At these extreme temperatures all metal surfaces would be hot enough to cause pain and serious accidents could result. The five coolers that will be used to lower the temperature from an unbearable 130° F. to a moderate working temperature of 80° F. can be obtained for approximately $1000. Installation is relatively simple and can be performed by the crew when rigging up. Water will be obtained from water supply wells to be drilled on the location.

The cost of siding and the coolers is a small price to pay to make possible the round the clock drilling in these hot climates. It is an investment that should pay off in work and morale. —**The End**

A performance report from
The La Gloria Corporation
on the First **Clark**
HMAB-10 "Midget Angle" packaged
compressor station installation

satisfactory"

Now over 7000 hours on stream

After 7000 hours of hard 24 hour a day service the performance of the first HMAB-10 Midget Angle installed is reported as being "highly satisfactory." There has been a complete absence of mechanical failures with only routine maintenance required.

The HMAB-10, installed at Waskom, Texas, is a completely self-contained packaged compressor station developing 550 bhp. The La Gloria Corporation is using it to gather gas at 50 psig. and compress it in two stages to 980 psig. Subsequent to after-cooling, the gas is piped to a gasoline plant where it is stripped and sold to a pipeline company.

Similar in appearance to the smaller HMA, the new unit incorporates the basic design features of the HMA as well as many new innovations. Foremost of these is a new radiator and hydraulic radiator drive. Both the radiator and drive have completely measured up to expectations with flawless operation.

Substantial savings in erection time were realized at Waskom because the HMAB-10 was delivered as a factory tested, completely assembled unit. Balanced/Opposed design greatly reduced foundation needs.

One very important consideration for users of this 550 bhp. unit is the fact that it is equipped with five compressor cylinders as standard equipment. If field pressures drop excessively, conversion to three-stage operation is easily accomplished. There is also ample physical space in the radiator to add another cooling section for additional intercooling. Demand for this new unit is heavy but new production facilities will soon be ready to speed deliveries. Be sure to get all the facts on the HMAB from your nearest Clark representative.

CLARK BROS. CO., OLEAN, NEW YORK
One of the Dresser Industries
Offices in Principal Cities Throughout the World

CLARK®

Packaged Field Compressors

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DRILLING HINTS

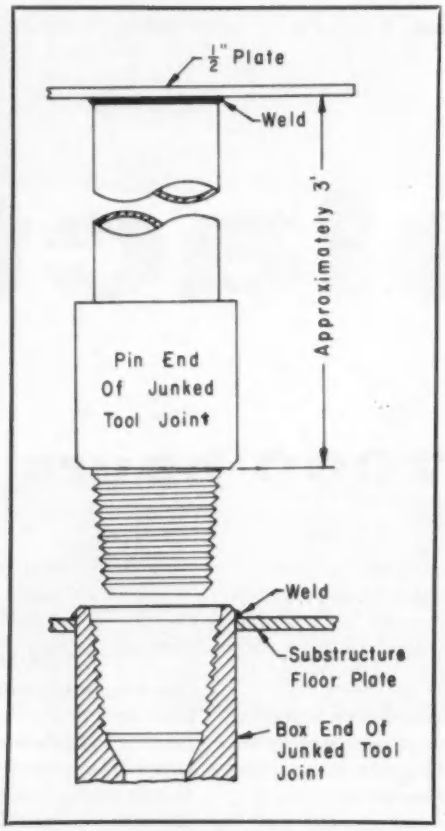
These How-To-Do-It Ideas Can Save You Money

$10 is paid for each illustrated acceptable contribution. Mail to The Editor, WORLD OIL, P. O. Box 2608, Houston 1, Texas.

Fix Removable Tool Stand From Junk Drill Pipe

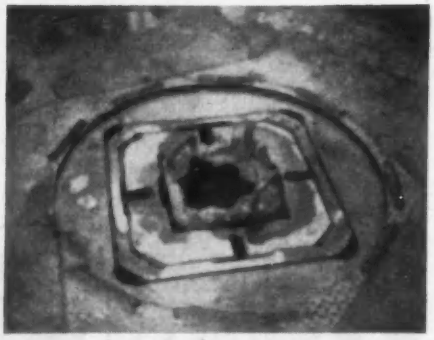
A convenient, removable stand for an electric grinder, a vice, a small work table, etc., can be made from a junked joint of drill pipe. Cut a round hole in the substructure floor plate, insert the box end of the joint so that the joint face is almost flush with the plate and weld into place.

Cut the drill pipe about three feet above the pin end and weld on a flat plate. Screw pin into box and install grinder, vice or other device on plate. When tearing down to move, unscrew upper section and transport in rig doghouse.



Rotary Table Safety Stops Made From Angle Iron

When coming out of the hole with the pipe, it is not uncommon to spin the pipe out with the rotary table. Where the surface of the rotary table and the floor is wet and slick from the drilling mud, accidents can happen if one of the crewmen were to slip toward the rotary table while it was spinning. Also, when pulling slips, it considerably helps when there is stop or ledge next to the rotary table where the crewman can brace his foot while taking an upward strain on the slips.



One contractor welded 1-inch angle iron, 8-inches long, around the edge of the rotary table. These 8-inch pieces were spaced approximately 10 inches apart with the angle up. This provides a foot stop so that the crewman could brace his foot against these pieces of angle iron while pulling the slips and while working around the rotary table. These pieces of angle iron welded to the rotary table can prevent many an accident and injury to employes.

Framework Guard Reduces Breakage in Floodlights

Breakage that frequently occurs when flood lighting equipment is broken down and stacked when the rig is moved can be reduced materially by investing a few hours of a welder's time in building a light framework guard around each light unit.

The lamp illustrated, resting on a small metal platform atop a self-supporting 2-inch pipe standard, is equipped with a guard of ¾-inch pipe

THEY HAVE THOUSANDS OF OIL WELLS

...right up there!

Engraved on the mind of your H. C. Smith field service man are the details of hundreds – perhaps thousands – of wells that he has known, first-hand. He knows your part of the oil country with the intimate knowledge that comes only with years of experience in the area. And he has added to his personal knowledge with drilling information absorbed from the reports of other skilled H. C. Smith field men working in all the active oil centers of the country.

Their knowledge and experience are all yours, any time you feel you can use any of it. Just ask... your H. C. Smith man will be at your rig when you want him, glad to give you any information he can on making hole faster, straighter and easier.

-every bit the best!

H C Smith
OIL TOOL CO.

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BRANCHES IN ALL PRINCIPAL OIL CENTERS IN THE UNITED STATES AND CANADA

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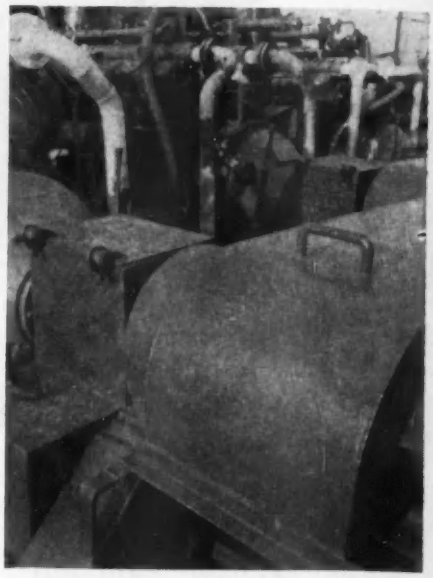
welded in such a way as not to interfere with all normal adjusting or servicing of the lamp; yet is sufficiently sturdy to guard against accidental breakage when it is lowered and stacked on the truck along with other equipment. A similar guard, though somewhat larger, is made for units having two lamps mounted side by side or back to back.

The small amount of time and materials involved in such a guard is more than offset by savings resulting from fewer broken lamps.

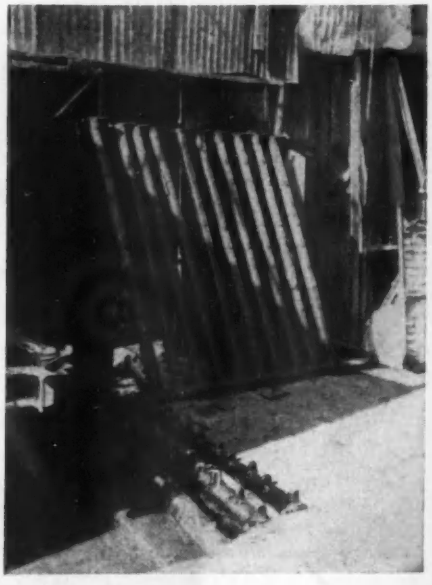
Heavy Guard Unit Permits Easy Coupling Inspection

Safety and utility are combined inexpensively in the method employed by one contractor in covering the couplings on drive shafts between engines and the mud pump drive group. Since a certain amount of traffic normally exists through the engine-pump group at this point, the guard was made of heavy diamond plate material and so designed as to provide two steps up and two steps down.

Of all-welded construction, the unit is provided with a hinged top plate



to allow easy inspection and servicing of the coupling. Hinges for the plate are from salvaged rotary chain. The entire housing may be removed as a unit simply by removing cap screws which attach it to several slotted clips welded wherever convenient on the adjacent I-beam base.



Sectionalized Pipe Stand Simplifies Fluid Drainage

More complete drainage of pipe and recovery of expensive drilling fluids while drill pipe is standing in the derrick is facilitated by the use of a unitized, multi-section base on which pipe stands are racked. The base consists of a number of equal-length sections of drill pipe, each of which, in turn, is equipped with a row of pins.

Individual stands are set over the pins which, actually, are short lengths

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'Most everything you buy is purchased by brand name—even the pack of cigarettes in your pocket.

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JENSEN JACKS

of sucker rod run through holes from bottom to top, bent over, welded to itself and welded to the pipe. One end of each section is equipped with a short pipe sleeve; the other end with a piece of plate that serves as a leg when it rests on the derrick floor. The sleeved ends, slid over a horizontal length of pipe as shown in the photograph, allow rotation of each section through a vertical angle of more than 90 degrees to stand up and out of the way when not needed, or when hosing down the floor. While pipe is being racked, drilling fluid drains to the floor, out over a sloping trough to the edge of the floor, then down a long sheet metal trough to the mud pit.

Magnetic Fishing Tool Saves Time and Money

On inland-type drilling barges that operate in approximately 12 feet of water, it is not unusual to lose things like wire-line clamps or small hand tools over the side. One contractor has provided his barge with a strong magnet to which is attached a piece of sash cord enabling crew members to immediately fish for any metal objects lost overboard.

This magnet is small and easily stored in a handy place where it is available when needed. The use of this magnet has cut down on the number of hand tools that have been lost and has provided a savings also in parts and time needed for replacement of parts when lost.

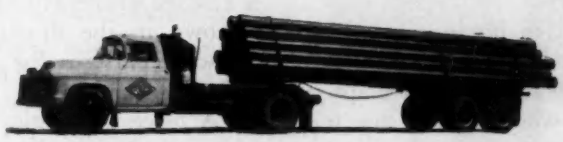
Congrats and $25 to W. S. Herron, Jr., Norman, Okla., for this quip.

"..he wants to borrow our separator"

Night is just another work "day" at the big Lone Star Steel plant. The beehive of activity and the red glow of molten steel are Joe Roughneck's assurances that we are making API casing, tubing and line pipe at full capacity.

Joe Roughneck (heart of the oil and gas industry) knows that all Lone Star pipe is quality checked repeatedly . . . and *fully normalized*. What's more, Joe knows that our new open hearth furnace and new stretch-reducing mill are growing toward completion at full speed. One day there'll be more Lone Star API quality pipe.

Neighbor, wherever you are, specify Lone Star and we both get a good deal.



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PRODUCTION HINTS

These How-To-Do-It Ideas Can Save You Money

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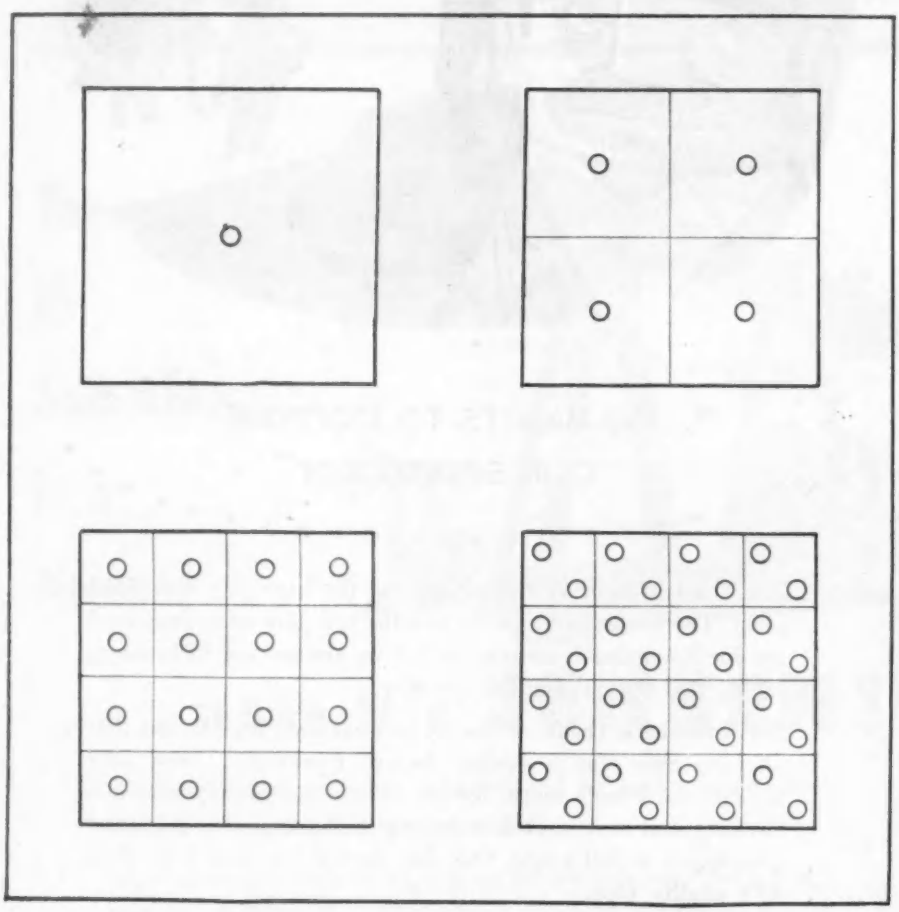


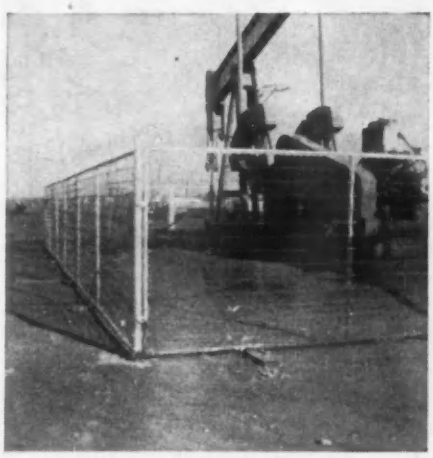
Template Aids Well Spotting

As an aid to landmen, geologists, draftsmen etc., who are responsible for keeping lease and field maps current or even when drawing new maps, a simple template can be made to save a considerable amount of time. This is especially true in areas where the standard 640-acre section prevails. In the accompanying sketch is shown a template devised for a 640-acre section. This template would be made to the most popular scale or scales used within any one company —as for instance 1-inch = 1 mile etc. Shown in the drawing are popular spacing patterns for 160, 40, 20 and 10-acre spacings.

A piece of plastic is obtained and is marked according to the various spacing patterns desired. One-eighth-inch holes are then drilled and the well locations can be drawn in or spotted accordingly.

These templates can be made up for as many prevailing map scales as are used within any one company or company division. In the fourth part showing the 20-acre spacing pattern, a 10-acre spacing is used simply by reversing the scale.

The use of this template actually assumes that spacing is on standard location. There has not been any shifting of locations due to obstruction, roadways etc.



Separate-Sectioned Fence Can Be Easily Removed

A desirable fence around a well, battery or other oil field equipment is one that can be partially or completely removed. Removal without putting slack in the wire or loosening the posts reduces the necessity of fencing a large area and enables easier access to the equipment.

This is especially true for a pumping well where a pulling unit must be used and room is required to lay down rods and tubing, or where it is necessary to make use of a truck to dismantle part of the unit or engine.

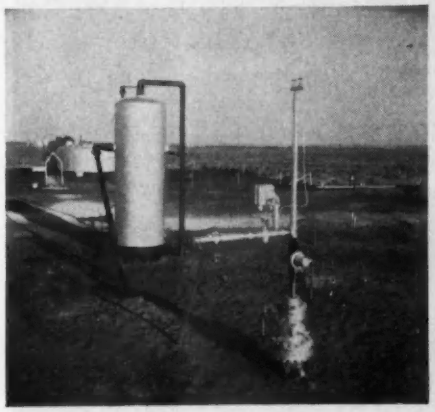
A fence easily removed may be constructed utilizing 2-inch pipe cemented in the ground two feet deep with a collar at ground level. Two-inch pipe of desired height can then be made-up into the collar for posts. Each section, being an independent

part of the fence, is built from 1-inch pipe with suitable bracing. Wire is stretched and tied to each section. When completed, attachment of each section to the 2-inch posts can be made with 2-inch to 1-inch pipe clamps.

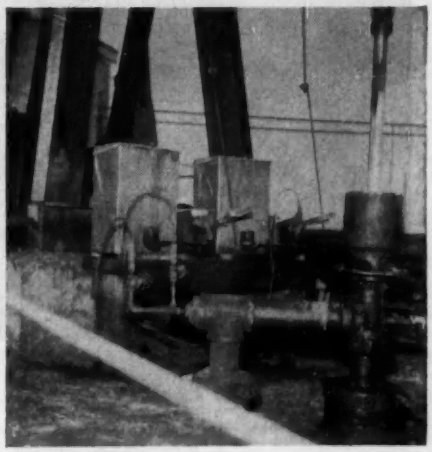
The fence in picture is made up of sections 5 feet high and 14 feet long with a vertical brace in the middle. Any single section or all sections can be removed along with the posts in a matter of minutes and erected back without any slack in the wire or loose posts. Because of these advantages, therefore, the fence need be only large enough for the pumper to do his work around the well.

Tubing Head Riser Allows Gas for Intermitter Valve

Where it is necessary to install a quick acting valve on the flow line to control high gas oil ratios, the gas supply line is usually connected into the casinghead. However, when the well contains a packer on the tubing, there is no gas to operate the intermitter valve. A simple means of supplying gas pressure may be arranged by putting a nipple on top of the tubing head and taking the gas from the top of the space provided. The oil production will not rise very far in the pipe as the well is continually making gas to replenish the amount used to operate the intermitter.



The valve is installed in the usual manner on the side of the tubing head with the proper size orifice to allow the well to clean itself in a few minutes. The riser is screwed into the top of the tubing head and two needle valves are placed on a tee at the top. One of these valves is used to bleed down the system in case it is necessary to take it apart; the other is connected back to the intermitter. A pot is placed at the opening into the intermitter so that any carryover can easily be removed.



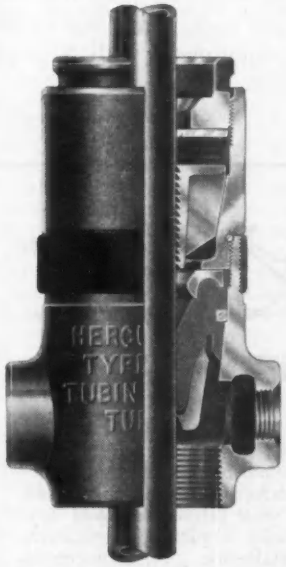
Tandem Connection Makes Injection System Flexible

The tandem hook-up of injection systems shown in the illustration make an extremely useful team.

They may both be used to inject

You get the most ECONOMICAL SERVICE from...

HERCULES TUBING HEADS

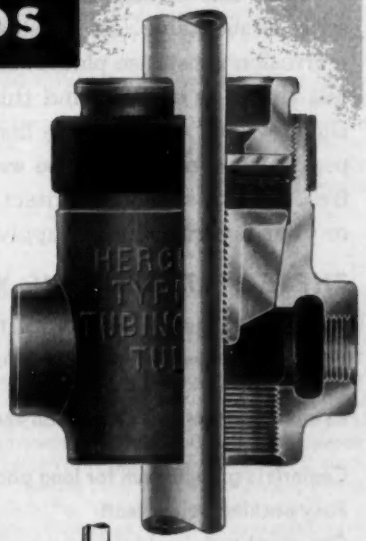


"TYPE J-5" TUBING HEAD

Ideal for flowing or pumping wells or for well servicing and repressuring projects. Will suspend 2" tubing to 5½" casing up to maximum of 180,000 pounds. Head is full-opening; constructed of pressure cast steel tested to over 4,000 psi. HERCULES original overhead packing arrangement and hinged slips facilitate installation and servicing. HERCULES Neoprene Tubing Stripper (2" - 2½" - 3") may be used in this head on wells flowing intermittently or to wipe tubing. Equipped with safety threads.

"TYPE J-5-S" STRIPPER TUBING HEAD

The dual purpose "Type J-5-S" Stripper Tubing Head is basically a "Type J-5" Tubing Head with a bowl (top section) screwed into the packing nut thread. The hinged slips, packing and packing nut are installed in the bowl (top section) with the tubing stripper in the body (lower section), thus permitting tubing to be run-in or removed under pressure. Test pressure is the same as the "Type J-5" Tubing Head.



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GENERAL OFFICES AND PLANT TULSA, OKLAHOMA

30 Church Street, New York 7, N. Y.

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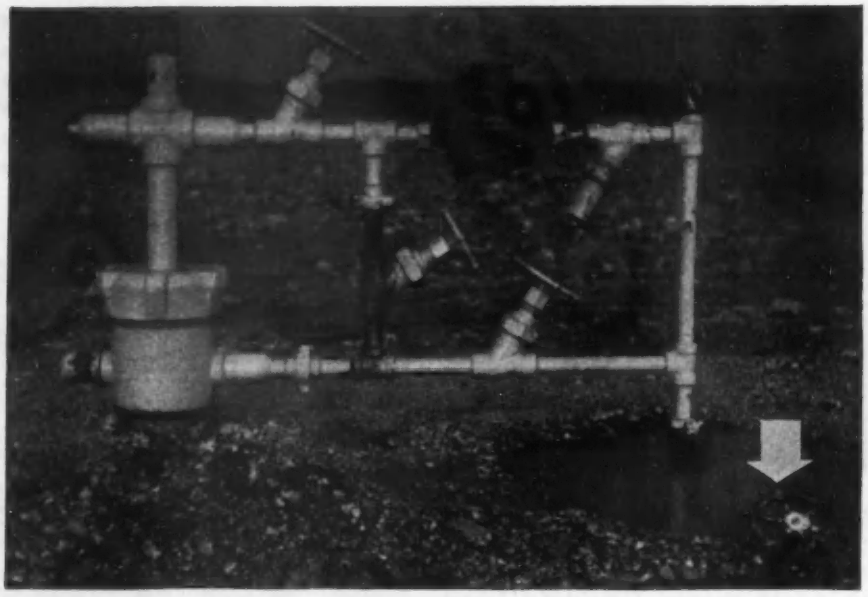


The right steel valve can

CUT MAINTENANCE COSTS

on water flood projects

It's easy to go wrong on valve selection for water flood injection well service. In West Texas, (note field conditions in photo above—one Edward globe valve installed below ground level) and elsewhere too, weatherproof valves are needed. Blowing sand, sun and rain increase valve maintenance—frequently make valves inoperative.

For this service Edward recommends **Fig. 2698** forged steel, inside screw globe valve (see illustration below) with bonnet exterior EValized (corrosion resistance plated) and precision built interior. Only the packing nut thread is exposed and this thread can't rust. Suitable for throttling, this low cost valve can be installed and forgotten. Make sure you aren't paying good money for the wrong *type* valve on water flood projects. Get free, *expert* assistance. Contact your nearest Edward oilfield representative, or your favorite oilfield supply store.

THESE FEATURES SAVE YOU MONEY!

Free flowing, no pockets to collect sediment!

EValloy stainless steel seats and disks borized in mated pairs!

EValized bonnet, with corrosion resisting threads!

Centerless ground stem for long packing life!

Easy packing adjustment!

Oversize handwheel for easy operation!

Forged steel bodies and bonnets!

Fig. 2698—
2000 lb WOG
Globe
Stop Valve

Edward Valves, Inc.

Subsidiary of

ROCKWELL MANUFACTURING COMPANY

1214 WEST 145TH STREET EAST CHICAGO, INDIANA

PRODUCTION HINTS . . .

inhibitor when additional volume is required. When necessary, one is used to supply inhibitor while the second injects an emulsion breaker.

The system is simple and flexible. Installation costs are at a minimum, and application is at a peak.

Install Shopmade Manifold For Testing Production

The illustrated manifold is used to divert crude to test production facilities. It is filled with hammer unions to simplify and speed installation if more wells are tied in and a manifold with additional lines is required.

A piece of 4-inch pipe in the unit allows for expansion and dampens back pressure on the well. Fittings for testing the effluent are attached to the line at the left and right hand ends of the photo. This allows production to be removed from the line, tested and put back in the line to the production equipment with a minimum of effort.

How-To-Do-It Ideas Earn Money, too!

WORLD OIL editors want how-to-do-it ideas, so your favorite short cut or invention could put money in your pocket! Write down the substance of your latest ideas and send them in with a picture or drawing of the installation . . . if accepted, $10 for each idea will be yours. Send those money-making ideas today to Hints Editor, WORLD OIL, P. O. Box 2608, Houston 1, Texas.

What's Happening

AMONG MEN IN THE INDUSTRY

Howard G. Schoenike, economic geologist of Houston has announced his resignation as production geologist for the Baroid Division of the National Lead Company in order to devote full time to domestic and foreign consultation as a mining geologist. His headquarters will be at 4039 Turnberry Circle, Houston. Schoenike had been with Baroid for the past 5½ years and had been engaged by them for examination, evaluation and exploration throughout the world. Before joining Baroid, he was exploration geologist for the Butler Brothers Mining Company of St. Paul, Minn., and the M. A. Hanna Company of Cleveland, Ohio. He has ten years of varied international experience in metallic and non-metallic minerals. His last assignment before coming to Houston was as geologist-in-charge of the Riddle, Oregon Nickel Exploration for the latter company.

Howard G. Schoenike

•

J. M. Clevenger, district production superintendent for **Sinclair Oil & Gas Company** at Big Spring, Texas, has been promoted to assistant division superintendent for Sinclair's Offshore division and transferred to New Orleans. **Robert A. Bonnell, Jr.,** assistant district superintendent at Odessa, Texas, was promoted to district production superintendent and transferred to Big Spring to succeed Clevenger. **Cuyler G. Confer,** intermediate petroleum engineer at Hobbs, N. M., was promoted to assistant district production superintendent and transferred to Odessa.

•

George B. Magruder, Jr., a veteran in the oil industry and a vice president of Southern Production Company, Inc. until the acquisition of its oil and gas properties by Sinclair Oil & Gas Company, has resigned from an executive position with Sinclair to enter the oil business as a consultant and operator. Magruder will open an office in Fort Worth shortly. Magruder first engaged in the oil business with Gulf Refining Company in Shreveport, La. He was later with Texas & Pacific Coal and Oil Company for six years and with Marland Oil Company for four years. In 1929, he joined Danciger Oil and Refining Company in Fort Worth and was a vice president of Danciger when it merged with Southern Production in 1950. Magruder was subsequently named a vice president of Southern Production.

•

Humble Oil & Refining Company's Production department announced the following personnel changes. **R. R. McCarty,** former assistant superintendent of the Southwest Texas division in Corpus Christi, Texas, was named superintendent of the Western division in Midland, Texas. McCarty replaces **J. W. House,** who resigned recently. **R. C. Granberry,** former assistant chief petroleum engineer in the Petroleum Engineering division, Houston office, replaced McCarty as assistant superintendent of the Southwest Texas division. **O. L. Furse,** former assistant division superintendent of the East Texas division, was named superintendent of the Eastern division in New Orleans, succeeding **S. S. Langford,** who is no longer with the company. **John G. Calvert** succeeded Furse as assistant division superintendent of the East Texas division, and **H. H. Meredith, Jr.** became East Texas division petroleum engineer, replacing Calvert. **R. L. Pinion, Jr.,** was transferred from the Southwest Texas division office in Corpus Christi to the Civil Engineering division, Houston office, as a division civil engineer.

•

William K. Warren has been elected president of the **International Petroleum Exposition** in Tulsa, succeeding the late **W. G. Skelly,** who served as head of the exposition for over 30 years. Warren is chairman of the board and chief executive officer of the Warren Petroleum Corporation and a director of Gulf Oil Corporation. The new president will spearhead the exposition's next show to be held May 14 to 23, 1959, which will commemorate the 100th anniversary of the Drake well, the first oil well drilled in the U. S. Warren has been on the board of directors of the exposition for over 20 years and a member of the executive committee since 1952.

William K. Warren

•

Garvey Drilling Company announced the promotion of **Frank G. Kozak** to the position of contact manager, and the appointment of **Bill Garms** to the post of Rocky Mountain contact representative. Garms was previously associated with ACC Diamond Coring and prior to that with Christiansen Diamond Products. He succeeds Kozak who represented Garvey Drilling Company in Denver for the past year. Kozak, in his new position, will assume the responsibility for the direction and development of the Garvey Drilling Company contact program. Kozak will work out of the central field office at Great Bend, Kansas.

•

Gulf Oil Corporation announced three top-level personnel transfers in its Production department. The new assignments will bring to Pittsburgh **E. D. Brockett, Jr.,** vice president and manager of Gulf's Houston Production division. Brockett will become coordinator, Production department. **S. G. Sanderson,** vice president and manager of Gulf's Tulsa Production division, will become manager, Houston production division. **N. C. Simpson,** operations coordinator for the Western Hemisphere, Production department in Pittsburgh, will become manager, Tulsa production division. All three men have long terms of service with Gulf.

•

S. A. Berthiaume has been appointed an assistant to the vice president, **E. R. Fillay,** in charge of **The Texas Company's** Domestic Producing department. Berthiaume has been assistant general manager of the department at Houston since 1954. In 1935 he became an instructor in geology at Cornell University. After two more years of teaching at Cornell he joined Texaco as a geologist at Houston. He was appointed assistant manager of the Producing department's Rocky Mountain division at Denver in 1950, and in 1953 he was made assistant to the general manager at Houston.

S. A. Berthiaume

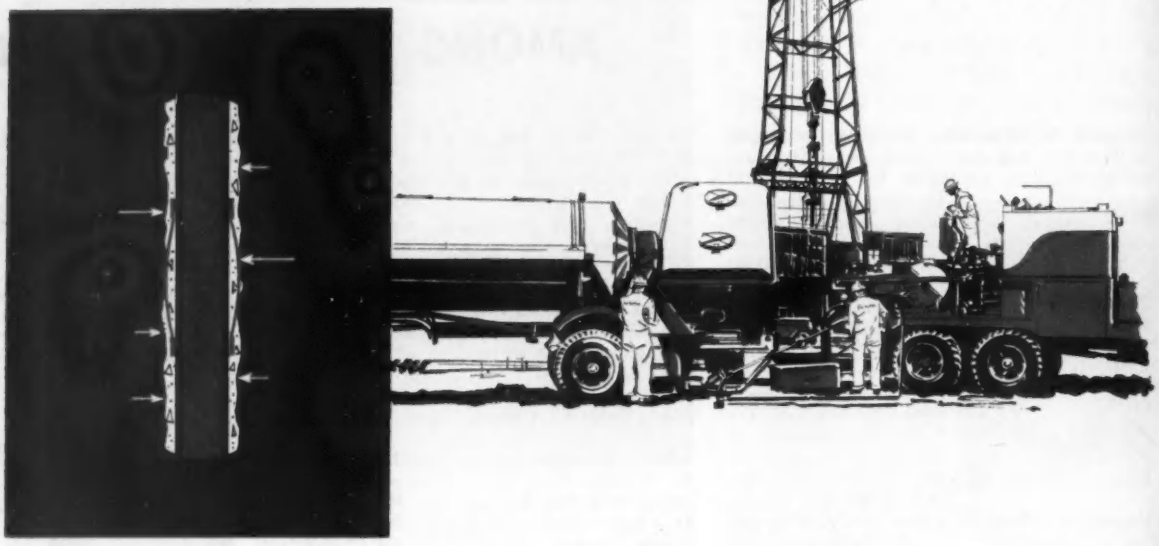
•

Robert B. Capps has been named division manager of the Southern division Exploration office of **Kerr-McGee Oil Industries, Inc.,** in New Orleans. Capps had been for the past three years a staff geologist in the company's Oklahoma City headquarters. He returns to New Orleans, where he worked as a geologist for four years beginning in 1950, to fill the vacancy created by the resignation of the division manager.

•

Creole Petroleum Corporation announced that all directors of the company were re-elected and also that **H. A. Cottin** and **J. F. Holmes** have been appointed assistant comptrollers of the corporation. Cottin has had 22 years of service with Creole in Venezuela. Holmes joined Creole in 1948 as a procedures accountant. At the present time he is coordinator of procedures, statements, audits and electronic data processing planning at the company's office in Caracas. Directors of the corporation re-elected are Messrs. **George L. Burr, W. L. Butte, L. Cade, H. W. Haight, H. A. Jarvis, Charles Leet, L. E. Lowry, R. E. Mays, H. A. Metzger, Dr. S. Vazquez, H. J. Wright** and **Dr. G. Zuloaga.**

Officers of the corporation re-elected by the board are president, Haight; executive vice president, Jarvis; vice presidents, **Metzger** and **D. E. Stines;** secretary, **E. J. Mundy, Jr.;** treasurer, **J. H. McCutchan;** comptroller, **J. E. Andrews.** The board also made the following reappointments: assistant comptrollers, **R. Prince** and **H. D.**



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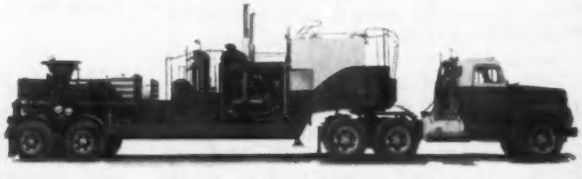

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HEAVY DUTY CENTRALIZERS

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SLIM HOLE CENTRALIZING

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Horne Well Service Co.....3-5396
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HOUSTON, TEXAS
Assoc. Eng. & Eqpt., Inc.....CA 5-1103
KILGORE, TEXAS—B. M. Davis.....5541
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Rainbo Service .....Main 4-3598
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Luccous Service & Eqpt. Co.....MU 2-1631
NEW ORLEANS, LOUISIANA
Assoc. Eng. & Eqpt., Inc.....VE 5-4983
OKLAHOMA CITY, OKLAHOMA
Rainbo Service Co.....ME 4-2131, ME 2-3045
PETTUS, TEXAS
Eddie Jones Eng. Co., Pettus 16; Beeville, FL 8-1218
SHREVEPORT, LOUISIANA
Cameo, Inc. 8-3615
VICTORIA, TEXAS—Cameo, Inc.....HI 3-9521
WHITTIER, CALIFORNIA
Kline Wire Line Co.....OX 3-2731
WICHITA FALLS, TEXAS
Hudson-Eads, Inc. 2-3767, 2-8584, 3-4690

Schersten; assistant secretaries, G. J. Berkel, Jr., C. F. Lindsley, Jr., and E. T. McNamara; assistant treasurers, C. J. Barrientos, A. E. Becker, Jr., Munday, Jr., and B. M. Owen.

•

K. T. McCamman is the new production manager for **Shell Oil Company's** San Joaquin division headquartered at Bakersfield, Calif. McCamman, who has served with Shell for 22 years, has been the division production superintendent for the Coastal division headquartered at Ventura, Calif. At Bakersfield, McCamman will replace **R. R. Robison**, who recently transferred to Farmington, N. Mex., as manager of the new Farmington Production division which will develop Shell's discovery holdings in the Four Corners area.

•

Sinclair Oil & Gas Company, producing subsidiary of Sinclair Oil Corporation, announced a series of executive promotions to broaden the operating company's top management structure. **H. B. Smith**, since 1953 president of Sinclair Oil & Gas Company was elected chairman of the board and chief executive officer to succeed **H. L. Phillips**, who will continue as a director. **W. H. Morris**, vice president, Sinclair Oil Corporation, and formerly president, Sinclair Pipe Line Company, was elected president to succeed Smith. He also was named a director. **J. W. Jordan**, executive vice president of Sinclair Oil & Gas Company, was elected vice chairman of the board of directors.

Executive officers for administration and operations also were named. **J. N. Johnson**, vice president and assistant to the president was elected executive vice president for administration, a newly-created position. He also becomes a director. **J. B. Kennedy**, a director, vice president and manager of the Houston division, was elected executive vice president for operations, also a newly-created post. He will be transferred to Tulsa. **D. R. Gearhart**, vice president and a director of Sinclair Oil & Gas Company who recently was elected president of Sinclair Canada Oil Company, will continue in charge of all Sinclair exploration and production in Canada.

•

S. Z. Natcher

S. Z. Natcher has been named manager of public relations by **Standard Oil Company of California**, in San Francisco. He has been with SoCal since 1938 and has served in London, England, during the past two years as president of Iran California Oil Company, SoCal's participating subsidiary in the Iranian consortium.

•

John E. Swearingen, executive vice president of **Standard Oil Company (Indiana)**, was elected a member of the board of directors of the American National Bank and Trust Company of Chicago. He was named executive vice president of standard Oil in 1956 with the primary responsibility of coordinating the activities of Standard with such prinicpal subsidiaries as Pan American Petroleum Corporation, Service Pipe Line Company, Indiana Oil Purchasing Company, Utah Oil Refining Company and American Oil Company. He was elected a member of Standard Oil's board of directors in 1952.

•

Edward D. Mellinger was appointed editor of the American Petroleum Institute "Quarterly." Mellinger, who had been serving as consulting editor, succeeds **Walter Henry Nelson**, who has resigned. Mellinger has been with the Institute since 1948.

•

Blanco Oil Co. has made a reorganization in the management. New appointments are **George C. Beaury**, vice president and treasurer; **James M. Gaines**, vice president and treasurer; **Howard R. Branch**, secretary; and **John H. White**, assistant secretary; Members of the board are **Hugh Halff, Jr.**, Beaury, **Arnold S. Askin**, Gaines and Branch.

•

McRae Oil & Gas Corporation elected one new director and re-elected all other directors. **Robert E. McCormick**, corporate executive and member of the New York Bar is the new member of McRae's board of directors. Re-elected were: **Donald Royce**, partner, William R. Staats & Co.; **E. J. Evans**, partner, Eastman Dillon, Union Securities & Co.; **Daniel J. Pickrell**, petroleum consultant; **Dan H. Sebastian**, assistant vice president, United States National Bank of Denver; **Wilbur Rocchio**, executive vice president, McRae Oil &

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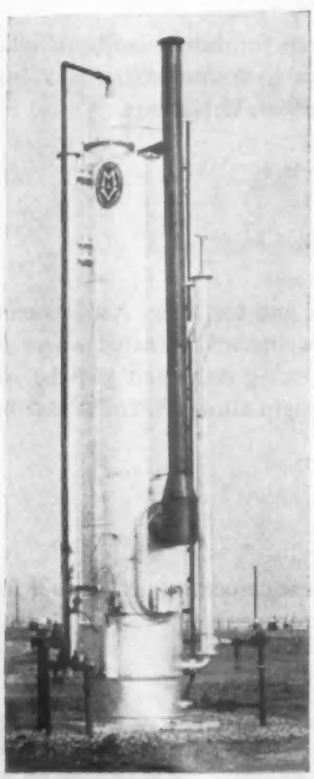

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Gas Corporation; and **Paul R. Brokaw**, secretary-treasurer, McRae Oil & Gas. All officers were re-elected. They are: **J. A. McRae**, president; Rocchio, executive vice president; **A. N. Brown**, vice president; **Brokaw**, secretary and treasurer; **E. C. Dorroh**, president of Roden & McRae Drilling Corporation, a wholly owned subsidiary; and **T. S. Rodgers**, vice president, Roden & McRae.

•

Phillips Petroleum Company has advanced **O. D. Thomas** to the newly created position of foreign exploration director in its Foreign department and has promoted **J. R. Leonard**, formerly division exploration geologist at Amarillo, Texas, to succeed Thomas as southwest regional geologist in the Land and Geological department at Bartlesville, Okla.

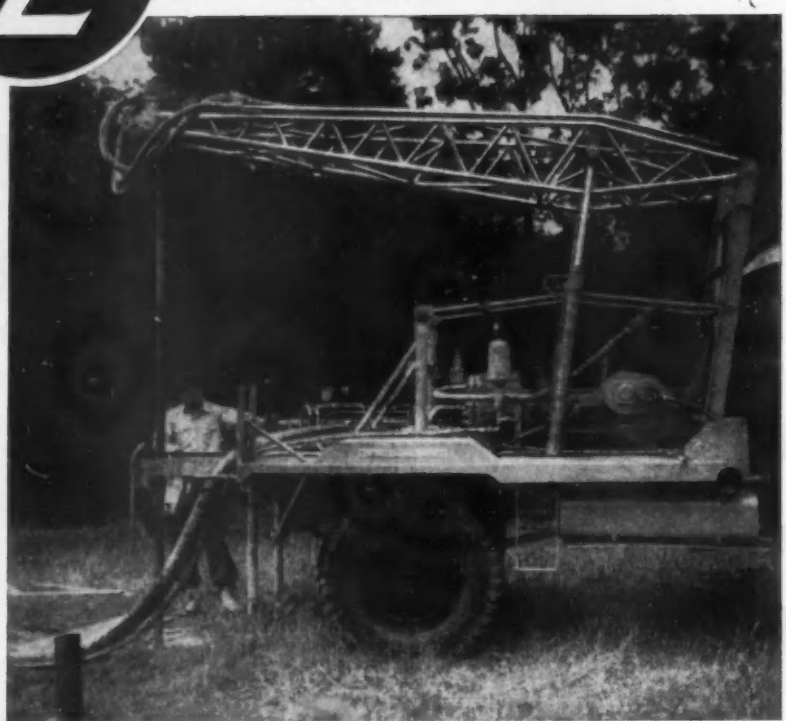
L. L. Logue, formerly of Exploration Surveys Inc., of Dallas, has disposed of all his stock interests in Exploration Surveys and affiliated companies in order to devote full time to his activities as an oil operator. Logue, as partner in the firm of Logue and Patterson with offices in the Meadows building, Dallas, has been active in the oil business since January, 1956. He was employed by Creole Petroleum Corp. in Venezuela from 1937 to 1941. In 1946, he helped incorporate Exploration Surveys, first serving as secretary-treasurer and later as vice president. Up until the time he became active in the oil business, Logue was technically engaged in geophysical and geological interpretation and research.

L. L. Logue

•

William A. Skees has been appointed district geologist for **Pan American Petroleum Corporation** in Corpus Christi, Texas. Skees is transferring to Corpus Christi from Midland, Texas, where he had been located since joining the company in 1951. In Midland he has served in several capacities, most recently as area geologist. He held the latter title for the past two and a half years.

DRILLMASTER 300 P.A. ROTARY DRILL



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The arm, and thus the rotary head which is mounted at the rear of the arm, is raised and lowered by jacks mounted a short distance to the rear of the arm front pivot point. In order that the rotary head shall travel up and down on a vertical straight line, a system of links is attached towards the front end of the arm, and to the front frame (about the top end of which the front end of the arm pivots); these links move the front pivot point of the arm forwards and rearwards thus maintaining the position of the rotary head above a fixed point. The system of links is a modified form of the well known "Scott-Russell" straight line motion and causes the rotary head to travel on a vertical straight line over the length of movement permitted by the jacks.

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DEATHS

Hugh Roy Cullen, 76, multimillionaire oil man and philanthropist, died July 4 in Houston. His gifts, mostly to education and medicine, totaled over $180 million at the time of his death. Cullen headed the Quintana Petroleum Company as president at the time of his death. Known as one of the most successful wildcatters, he discovered the valuable Pierce Junction field in the 1920's, which is still producing. Beginning work with the equivalent of a fifth grade education, Cullen first worked as a cotton buyer and then entered the real estate business. He then went into partnership with the late Jim West in the oil business. It was in the 1930's that Quintana was formed, and the partnership was dissolved.

Leo Carle McEvoy, Sr., 75, former Tulsa independent oil man and retired communications director for baseball's American League, died May 18 in a St. Petersburg, Fla., hospital.

Addison Browne Dally, 95, died in Pittsburgh, Penn., recently. He was chairman of Hiawatha Oil and Gas Company and of Penn-Ohio, Company and a director of Plymouth Oil Company. Dally developed oil fields in western Pennsylvania and nearby West Virginia. During his career he has also held prominent positions with Manufacturers Light and Heat Company, Benedum-Trees Oil Company and Arkansas Natural Gas Company.

John Henry Phelan, 79, died May 19 in Beaumont, Texas. He was secretary and treasurer of Yount-Lee Oil Co. and helped organize it.

Henry B. Welp, 72, died May 14 in a Guthrie, Okla., hospital. He was an independent oil driller and contractor.

Walter R. Reitz died in an Oil City, Penn. hospital May 25. Reitz was a retired board chairman of Quaker State Oil Refining Corporation.

Isaac Herbert Caywood, 52, geologist, Bartlesville, Okla., died May 25 in a Vernon, Texas, hospital. Caywood was associated with the Indian Territory Illuminating Oil Co., in Bartlesville until its merger with Cities Service Oil Co., and was employed as a geologist with a Wichita Falls, Texas, firm.

What's Happening

AMONG SERVICE AND SUPPLY MEN

George B. Coale has been elected a vice president of **National Lead Company.** He continues as general manager of the company's Baroid Division. His headquarters will remain in Houston. Coale was employed by The Anaconda Company before joining National Lead Company in 1935 as chief engineer of the power plant at the Sayreville, N. J., titanium pigment operation, then as plant mechanical superintendent. Later he became chief engineer of the company. In 1949 he was transferred to Baroid as assistant general manager. He was named general manager in 1954.

George B. Coale

•

Roger O. Bachman was appointed Denver area sales engineer for **Edward Valves, Inc.**, subsidiary of Rockwell Manufacturing Company. Prior to joining Edward, he was assistant plant foreman, Cadillac Screw Corp., Belvidere, Ill., and, before that, served as third assistant engineer of the ship "S. S. Selma Victory" of the Farrel lines.

•

Martin-Decker Corp., Long Beach, Calif., has announced the appointment of **A. G. Herrick** as industrial sales manager. Herrick will direct the sale of heavy duty weight and tension indicating instruments. Prior to this appointment Herrick was sales representative for the Trailmobile Company in Cincinnati, Ohio. Former sales manager **Roy I. Boydston**, a veteran of 14 years with Martin-Decker, has been promoted to product engineer with responsibility for new product development.

•

R. F. Clinkscales has been appointed sales service representative for **Rector Well Equipment Company, Inc.**, and will make his headquarters in the company's Houston office. He joins Rector after five and one-half years as a partner in a well control firm. Prior to that he had been with Mike Hicks Tool and Cementing Company and Spartan Tool Company, and earlier had been employed as a tool operator for McCullough Tool Co., Alice, Texas, and in that company's Sales department, working in Texas and old Mexico.

•

Lane-Wells Company has announced the following personnel and location changes. **Ernest Snidle** has been transferred from Mt. Carmel, Ill., to Olney, Ill., as area manager. **O. T. Bright** is now sales engineer in residence at Mt. Carmel. **Maynard E. Weber** has been reclassified to district sales engineer trainee at Guymon, Okla., replacing **Roy Smith** who is now field service operator. **Lindsey B. Johnson**, district logging engineer at Oklahoma City, has been reclassified to district sales engineer and transferred to Perry, Okla. **K. W. Simmons** is now sales engineer in residence at Pawhuska, Okla. **Arthur L. Miller** has been reclassified to field service operating engineer in charge at the Sterling, Colo., truck station. **Claude I. Morris**, formerly field service operator in the Kansas district, was transferred to Williston, N. D., as district logging engineer. The Glendive area has been reclassified as a truck station. **Robert L. Westall**, operator in charge at Roundup, Mont., was transferred to Glendive as field service operating engineer in charge.

•

Robert K. LeRouax was assigned senior engineer in charge of Wellhead Equipment department and **John P. Oliver** as senior engineer in charge of Valve Products department for **Cameron Iron Works, Inc.**, in Houston. LeRouax has been with Cameron since 1952 in the Research and Patent Engineering department. Before joining Cameron, he was sales engineer with Hinderliter Tool Company and chief engineer of Oil Center Tool Company. Oliver joined Cameron in 1948 in product engineering. In 1956 he was made senior engineer in charge of Wellhead Equipment department, a position he has held until this new assignment.

•

A. H. Chapman

Alexander H. Chapman has been elected a director of **Aero Service Corporation.** Chapman, a consulting engineer with offices in New York City, was a Washington representative of Arabian American Oil Company prior to retirement last year, is also an advisor to the Military Petroleum Advisory Board.

•

John M. Smidl was appointed chief engineer of the Witte Engine Works of **United States Steel Corporation's** Oil Well Supply division. Smidl joined Oilwell in 1956 as assistant to the general manager of the Witte Plant. Prior to his employment by U. S. Steel he had been associated with Electro-Motive divisison of General Motors Corporation since 1939.

•

Cardwell Manufacturing Company, has announced the appointment of **Clyde M. Lackey** as domestic sales manager for the company. Lackey was formerly district manager for Cardwell in the Illinois Basin with offices in Mount Vernon, Ill. In his new position he will headquarter at the Wichita, Kansas, offices of the company. Prior to joining Cardwell, Lackey was employed by Buda Engine Sales and Service as district manager for their Rocky Mountain territory and Kansas.

George W. Gutekunst

C. H. Rieman

Gardner-Denver Company, announced the election of three new vice presidents. Elected were **George W. Gutekunst, C. H. Rieman** and **Brice D. Maddox.** Gutekunst was named general sales manager in 1954 and continues in this capacity. Prior to 1954 he served as Gardner-Denver's district manager in Los Angeles. Gutekunst has been with the Gardner-Denver sales organization since 1937. Rieman was formerly sales manager of mining and construction equipment until transferred to the Denver plant in 1955. He was named general manager of the Denver plant in February of this year. Rieman joined Gardner-Denver in 1937 and has served in sales in Quincy, Ill., and San Francisco, and as district manager in Duluth.

Brice D. Maddox

Maddox was appointed general manager of the Keller Tool Division, Grand Haven, Mich., last year and continues in this capacity. He joined Keller Tool Company in 1951 as materials control manager and in 1953 was named manager of employe relations. In 1955 Keller Tool Company merged with Gardner-Denver.

•

Walter S. Secrist was appointed chief engineer at the Nielsen Pump Works of **United States Steel Corporation's** Oil Well Supply division. Secrist succeeds **Edward E. Stevenson**, who was appointed special consultant at the Nielsen Works. Prior to his appointment, Secrist had ten years experience in the design and application of oil well subsurface pumps. He was employed by Oilwell in 1951.

•

Edward N. Spice was appointed district engineer production, Edmonton, Alta., Canada, for **United States Steel Corporation's** Oil Well Supply division. Spice was employed in 1954 as an engineer trainee at Wetaskiwin, Alta. Later that year he was appointed assistant to district engineer at this location and in 1955 was transferred to Red Deer, Alta., and in 1956 to Edmonton.

•

Joseph L. Hull, Jr., secretary and general counsel, for **Seismograph Service Corp.**,

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has been elected to the board of directors of the world-wide seismic firm.

At the end of World War II he entered the private practice of law in Tulsa, and in 1946 he joined SSC as assistant counsel. He was named secretary and general counsel of the firm in 1949.

•

Roy E. Nelson has been elected vice president of **American Gilsonite Company.** In addition to his new duties, Nelson will continue as manager of production in charge of all producing activities of the company, including the new gasoline refinery and coking plant now being built at Gilsonite, Colo. Nelson joined American Gilsonite in 1949 after serving in various refinery positions with Standard Oil Company of California. He has been largely responsible for American Gilsonite's new product, Gilsulate, which is used for insulating hot underground pipe lines.

Roy E. Nelson

•

Gordon N. Dow has been appointed general sales manager of **Leschen Wire Rope Division, H. K. Porter Company, Inc.** Dow has been successively territory salesman in the Detroit, Mich., area and sales manager of the Chicago district for Leschen.

•

Warren M. Benson, vice president, **Alten Foundry & Machine Works, Inc.,** has announced the appointment of **William Underwood** as manager of the new Alten warehouse in Oklahoma City. Underwood is a native of the Oklahoma-Texas territory and was previously associated with the Houston Oil Field Material Company. A complete line of Alten pumping units and parts are now available at the new warehouse.

William Underwood

•

Howard Rainbird was appointed area manager, tubular sales at Edmonton, Alta., Canada, for **United States Steel Corporation's** Oil Well Supply division. Rainbird was employed by Oilwell in 1947 at Calgary and transferred to Edmonton in 1949. In September of the same year he was named field representative at Edmonton and February, 1957, city representative, the position he held prior to his present appointment.

•

Fairbanks, Morse & Co., announced reassignment of three vice presidents and one plant manager and the promotion of four other executives. Reassigned are: **Robert H. Morse, III,** from vice president in charge of sales to vice president in charge of budgets and planning; **V. H. Peterson,** from vice president in charge of engineering to vice president in charge of sales; **John A. Cuneo,** from vice president and assistant to the president to vice president in charge of foreign operations. Cuneo will be in charge of the company's Canadian and Mexican operations as well as its Export division. **John C. Elmburg,** assistant general sales manager, was promoted to general sales manager, and **G. R. Anderson, Sr.,** former manager of the company's Kansas City, Kansas, works, to chief engineer. **C. E. Clausen,** manager of the St. Johnsbury, Vermont, works, was named manager of the Kansas City plant to succeed Anderson. **H. M. Goodchild,** chief engineer at St. Johnsbury, was promoted to works manager, and **G. R. Anderson, Jr.,** named chief engineer at the Vermont plant.

•

Edward V. Huda has been named to direct research and development for the Adhesives department of **Raybestos-Manhattan, Inc.,** Bridgeport, Conn. A project supervisor, Huda has been employed in the Research and Product Development department of the firm's Raybestos division since 1946. He worked on the Manhattan Project in 1941 and 1942. Later he served in the Chemical Warfare department of the U. S. Army.

Edward V. Huda

•

Ray Hartzog has been named sales engineer in the Houston area for **Waukesha Sales and Service, Inc.** He worked for The Texas Company and Union Oil Company of California in the Southwest for several years. His most recent position was in Washington State where he was office manager for the McGregor Carbon Forms Company.

•

M. E. Swaim was elected vice president—sales, a newly-created position, for the **National Supply Company.** He has been general manager of sales since January, 1956. Swaim joined the company at Tulsa in 1925, and served subsequently in various sales and field engineering capacities at Wichita, Kansas, and Clay City and Olney, Ill. He spent two years in the Engineering department at the company's Toledo, Ohio, plant and in 1944 was appointed manager, Plant Products division, at Houston. He was appointed sales manager, production equipment in 1948, and in 1954 became general manager of oil field sales.

M. E. Swaim

•

James W. Bozeman of Houston was elected executive vice president of **TUSCO Corporation,** formerly Tubular Service & Engineering Co. In his new position, Bozeman will be active in the management of

Mr. D. E. Vasser, President
Louisiana-Delta Drilling Corp.,
New Orleans, La.

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35 Miles Off Venice, La.

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Keeping your diesel-electric drilling power humming is the main point of ALCO's warehousing and service. All components of the ALCO diesel-electric plant are stocked in Beaumont, Tex., ready for speedy shipment to any Gulf Coast site. Diesel-electric field engineers are ready 24 hours a day.

Here is an example of ALCO service from Mr. D. E. Vasser, President, Louisiana-Delta Drilling Corp., New Orleans:

"One of our rigs had an outage not directly connected with ALCO equipment while drilling 35 miles off Venice, La. Within four hours two ALCO diesel-electric servicemen, one a graduate Electrical Engineer, were on the rig tracing the fault and beginning repairs. The outage had resulted from water in a junction box, not actually a part of the ALCO power package. But, just as if the outage had occurred because of an ALCO part, the field engineers made the repairs and had the rig running in the shortest possible time."

Service is only part of the complete story of the ALCO diesel-electric package. Its reliability is being proved every-day. The ALCO unit is built and backed by the pioneer of diesel-electric power—with over 12 million horsepower in service today.

For more information on the best diesel-electric power available, contact either Transportation Products Division, Dept. DR-3, Box 1065, Schenectady, N. Y., or Petroleum Industry Equipment Division, Bank of the Southwest Bldg., Houston, Tex. (CApitol 2-9076), or any ALCO sales office.

ALCO

ALCO PRODUCTS, INC.

NEW YORK

Sales Offices in Principal Cities

Locomotives · Diesel Engines · Nuclear Reactors · Heat Exchangers · Springs · Steel Pipe · Forgings · Weldments · Oil-Field Equipment

TUSCO's oil field service companies, its building material division and its Navion aircraft division. The new executive vice president formerly was president of the Tuboscope Company, a TUSCO subsidiary, and will continue as chairman of the board of Tuboscope.

•

B. J. Ramey was appointed **Tube-Kote, Incorporated**, general sales manager, **L. C. Edgar** as technical director and **Barnard P. Goodman** as research director. Prior to his new promotion, Ramey had been sales engineer and sales coordinator. Edgar has been associated with Tube-Kote for nine years. He has served in various technical and research positions during his employment. He will continue to report to **E. G. Holm**, former technical director, who was promoted to assistant general manager several months ago. Goodman before joining Tube-Kote was associated with a Houston paint manufacturer as a chemist. Prior to his promotion, he was a research chemist at Tube-Kote.

•

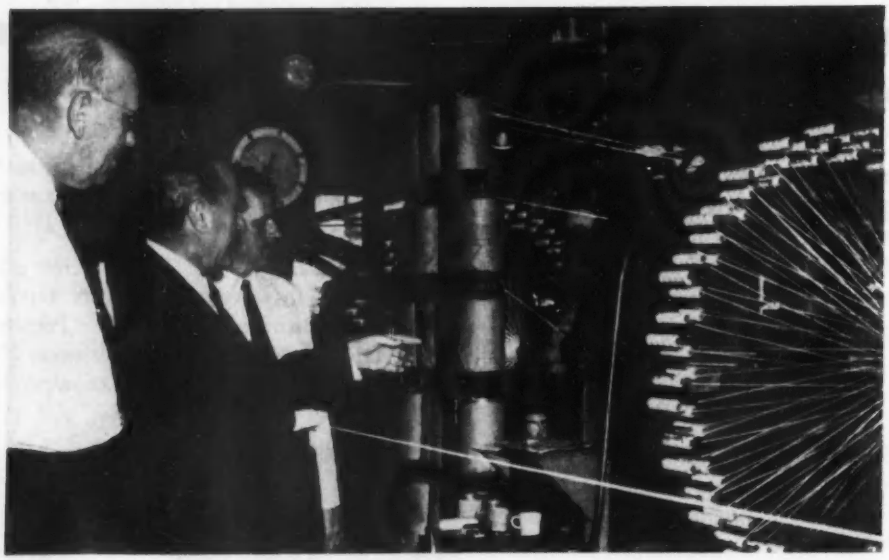
Harley C. Hanselman has been appointed sales engineer for the Perry, Okla., area, for the **Lane-Wells Company.** He joined the company in 1948 and prior to his present appointment was operator in charge at Hominy, Okla.

•

Harold N. Wilson has been elected secretary-treasurer of the **Parkersburg-Aetna Corporation.** Wilson, who has been with Parkersburg since 1929, has served as assistant secretary and treasurer since June, 1956.

Advice from the Top

Ted Sutter, president of Baker Oil Tools, Inc., explains lathe operation to three of his grandchildren at recent Scout-O-Rama held in Los Angeles Coliseum. Operation was one of several performed by Scouts in company-sponsored booth designed to help participating members of Bell, California, Troop 40 qualify for their machinery merit badge. During the exhibition the Scouts actually manufactured, from raw stock, lightweight aluminum water proof match cases.



Fibercast Corporation Plant Visitation

R. R. Burris, Sun Oil Company; J. A. Mussler, vice president tubular sales, Continental-Emsco Company; and Ned Smith, Sun Oil Company, visited The Fibercast Corporation plant in Sand Springs, Okla., recently. The occasion was to celebrate completion of the most recent expansion program which increased production to six times greater than a year ago. It was attended by over 300 purchasing agents, engineers and production management personnel from throughout the Mid-Continent area.

Delta IV In Commission; Delta V Is Launched

Marine Fabricating and Engineering Company of Houston, recently commissioned the second of four drilling tenders constructed for Perforaciones Delta of Caracas, Venezuela, and launched another which will be commissioned in the near future. The Delta IV was commissioned only 90 days after keel laying and 21 days after launching the 1320 gross ton vessel.

Officiating at the commissioning ceremony were Clarence Sprague, president of the Houston firm which has set several speed records in the construction of offshore vessels in the past six months; Joe Zeppa, president of Delta; Mark Gardner, Delta VP; George Stetson, Delta chief engineer; and Bill Cook and George Feingold, MFE chief engineer and general superintendent respectively.

The Delta IV, which measures 180 feet by 70 feet, features a 60-foot by 80-foot helicopter deck, a completely equipped work shop, a generator room with three diesel driven 60KW generators, office, galley and crew quarters for six men. Separate change rooms are provided.

The Delta V, also built for the Venezuelan firm by Marine Fabricating, is similar to the Delta IV and will be followed by Delta VI.

Sheffield Steel Celebrates Two Industrial Anniversaries

The Sheffield steel mill on the Houston Ship Channel and the 4000 men and women who run it celebrated two significant events in the industrial life of Texas recently. Fifteen years ago on April 24, 1942, the first steel was tapped from a Sheffield open hearth furnace. And during the current week workmen at the Sheffield mill have poured an ingot containing the 10 millionth ton of steel produced by the plant which pioneered in steelmaking in Texas.

Top officials of the Armco Steel Corporation of Middletown, Ohio, were in Houston to celebrate the two anniversaries. R. L. Gray, now president of Armco, and former president of Sheffield, heads the group of visitors. Others include L. T. Johnston, Armco vice president in charge of sales, of Middletown; W. S. Newell, manager of sales for the Sheffield division and C. E. Moore, also of Kansas City, director of public relations for Sheffield.

Top officials of the Sheffield division are L. H. Juengling, Armco vice president in charge of the Sheffield division; F. Ray McFarland, manager of the Houston division; J. George Miles, director of personnel relations; W. C. Higdon, assistant manager, Houston division, and R. W. Davison, manager of sales for the Houston plant.

Dowell Acidizing Station Opened at Andrews, Texas

Dowell Incorporated is operating out of its new Andrews, Texas, station. The station, opened recently will be used for acidizing service only. It is located about one and one-half miles south of Andrews on Highway 51.

Installed on the five-acre site acquired by Dowell recently, there is a 15,000-gallon acid tank, loading dock and field office.

W. B. Hart has been transferred from Kermit, Texas, to be station manager. Service engineers now working out of Andrews are R. D. Murphree and Rex Pensinger. L. E. (Tiny) Griffith, sales engineer, who has been in Andrews several years will continue to make his headquarters there.

Joe Stine's New Plant for Louisiana Offshore Operations.

U. S. Industries Organizes Regional Advertising Department

Opening of a regional Advertising department in Los Angeles to serve the West Coast divisions of U. S. Industries, Inc., has been announced. The new department, organized along the same lines as the Chicago Regional advertising office, will handle all advertising and sales promotion activities for Axelson Manufacturing Company, Los Angeles; Southern Pipe and Casing Company, Azusa, Calif., and Western Design and Manufacturing Corporation, Santa Barbara, Calif., all U. S. Industries divisions.

William O. Merritt is manager of the regional office. H. V. Jacobsen, has been appointed assistant manager.

Stine's New Shop Provides Service for Offshore Operators

Joe Stine, Inc., of Houston, announces that an all-new, fully equipped machine shop is now complete and in service in Harvey, La. This latest expansion represents a major addition to the facilities on the Harvey Canal for marine operators.

The plant is to be operated under the name of Harvey Machine & Fabricating Co., Inc., and will be under the general management of Tom Crain.

The plant is situated on a 15-acre site on Peters Road, near Harvey, with 800 feet frontage on the Harvey Canal and a 500 by 500 foot slip off the canal to accommodate almost any type of offshore vessel work. The building itself has 25,000 square feet and is 230 feet long. The crane runway is some 250 feet.

Newly-Named Dresser Subsidiary Has G. W. Walton as President

Ideco Division of Dresser Equipment Company has been reorganized and will be known as Ideco, Inc. G. W. (Jack) Walton was appointed president of Ideco, Inc.

G. W. Walton

Since 1954, Walton has been executive vice president of this Dresser subsidiary. Other officers reappointed in the new company in the same capacity as before include W. O. Cook, vice president in charge of engineering and manufacturing; G. G. Wilbur, assistant to the president and vice president in charge of export sales; and E. F. Shiels, vice president in charge of domestic sales.

Cameron Iron Works to Build Outside Morgan City, La.

Cameron Iron Works, Inc., announced plans to construct a 30,000 square foot plant, warehouse and office building on U. S. Highway 90 between Morgan City and Franklin, La.

Approximately 35 skilled craftsmen to assemble and repair Cameron drilling control and wellhead equipment will be employed initially. Cleaning and metallizing equipment will also be used to re-work corroded components of Cameron equipment used in offshore operations.

H. M. Barr, now head of Cameron's New Orleans sales office, will be in charge of the new operation.

ARCCO
ARCCO-Anubis
LIQUID GRAVITOMETER
For PIPELINES, REFINERIES, GASOLINE PLANTS
NOW 19 MODELS
MODEL R
This ruggedly built instrument of laboratory accuracy is ideal for quick checking and for continuous recording of Specific Gravity of liquids under line pressure. Changes in Specific Gravity of sample are recorded with a very minimum of time lag. Foreign liquids and gases are automatically purged from sample. No moving joints or stuffing boxes to cause friction or leakage. Temperature corrected, this precision instrument is adaptable to high pressures. Hundreds are in daily use in plants and refineries of major companies. Available in 19 Models for Recording, Signalling, Transmitting and Controlling. Send for Bulletin 111R-3.
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RECORDING CHART CO.
3113 E. 11th St. • Los Angeles 23, Calif.
AVAILABLE FOR EARLY DELIVERY
Send For Bulletin 111-R3

For more data on advertised products, use Readers' Service Cards, last page.

NOW . . .

in 3 sizes

14" – 20" – 24" Sheaves

8 – 12 – 25 Ton Capacities

Well Loggers

FLOOR BLOCKS

to meet your every requirement

Alloy steel flame hardened Sheaves mounted on double row Timken Bearings—Permanently sealed with J-M Klipper Seals.

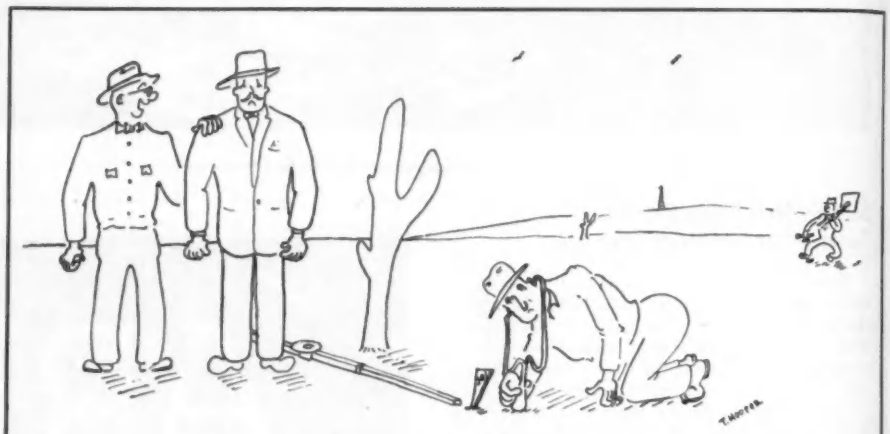
High-tensile aluminum housings reduce weight without sacrificing strength.

McKISSICK

McKISSICK PRODUCTS CORPORATION

Box 2496 Tulsa, Oklahoma

SQUEAKS from the BULLWHEEL



"It's a brand-spanking new type geophysical instrument, Colonel, and we got it from a Houston man for only $4000 . . ."

Preventive Measures

Mother: "When I was your age, young lady, a nice girl didn't think of holding a man's hand."

Daughter: "But, mother, nowadays a nice girl HAS to hold a man's hand."

One Plus One

Salesman. "Young man, this handbook is just the thing you need. It will do half your college work for you."

Engineer: "Fine, give me two."

Prestige Costs

America is still the land of opportunity, where a man can start out digging ditches and wind up behind a desk—if he doesn't mind the financial sacrifice.

Riding on His Coattail

Answering his doorbell a man found an old friend and a large dog standing on his porch.

"Come in. Come in!" he said.

His friend came in and sat down. Meanwhile, the dog put the man's cat to flight, knocked over a bridge lamp and several knick-knacks, finally making himself comfortable in one of the best chairs in the room.

When the guest rose to leave, the host said, with a touch of sarcasm in his voice: "Aren't you forgetting your dog?"

"Dog? I have no dog. I thought he was yours."

Think of It This Way

The life of a bill collector must not be so unpleasant. Nearly everybody asks him to call again.

Who's in the Gutter?

In the slum section of a large city three urchins were playing in the gutter when a Cadillac stopped across the street and a beauteous blonde alighted. She crossed the street, picked up one of the youngsters, hugged him, kissed him and looked into his eyes tearfully. Finally she put him back on his feet, filled his hands with candy, added some toys and emptied her coin purse in his small dirty hands. Then she returned to the waiting automobile and the chaufleur drove her away.

Finally one of the boy's playmates asked:

"Gorry be, Jimmy, who wuz it, yer Godmother or sumpin?"

"Naw," Jimmy replied, "that's me sister whut was ruined."

Nile Notes

"What did Mark Anthony say to Cleopatra when he discovered there was no bathroom in the palace?"

He said: "Why, Cleo, this place is uncanny!"

Early Retirement

Bore: "I'm a self-made man, that's what I am—a self-made man."

Listener: "You knocked off work too soon."

These Kids!

The small boy had just asked his father: "Where did I come from, Daddy?" The boy seemed to listen attentively and at the end of the explanation his father asked him, "What made you ask son?"

The boy was playing with an airplane model and replied casually: "Oh nothing 'specially, Dad, 'cept I heard the new boy at school say he came from Baltimore and I wondered where I came from."

Gleaned from Church

The little girl had not been behaving at church and as punishment her mother set up a small table in the dining room, informing her that she could not eat Sunday dinner with the rest of the family. When all were seated, the father bowed his head to give thanks. The room was quiet for a

Over 70 *Locations in the United States and Canada*

McCullough® REPORTS TO THE OIL INDUSTRY

Service *Anywhere Anytime*

New Services • • • New Tools • • • New Methods • • • Outstanding Results

SUPER FORMATION GLASS JETS INCREASE PRODUCTION 265%

This Colorado oil well had been jet perforated by another service company. Resulting production of 72 barrels of oil per day was not up to the standard of other wells in the area.

McCullough was called to reperforate the pay zone. 5½" O.D. 15½ lb. casing had been cemented through the productive interval at 5400'.

A 4¾" O.D. McCullough Super Formation Glass Jet Perforator with Steel Strip Carrier fired 26 shots in the formation. Production increased to 264 barrels per day —a gain of 192 barrels or a 265% increase in daily production.

Super Formation Glass Jets get outstanding results where ultimate maximum penetration is required.

Glass Jets Perforate 17 Zones in 7 Runs

Chemical Cutter Gives Assist on Tough Completion

This was a new well in a shallow Texas oil field. 2" tubing had been accidentally cemented in 4½" O.D. 9.5 lb. casing. Total depth was 2264'.

Rather than go to the expense of removing the cemented tubing, the operator decided to complete the well in a higher formation.

McCullough ran through the tubing to the top of cement with a 1¾" O.D. Chemical Tubing Cutter, made the cut, and free tubing was removed from the hole.

Seventeen zones were then perforated, four holes per foot, in seven runs by McCullough Standard Casing Glass Jets with Steel Strip Carriers. A total of 204 shots were fired.

Operator was well pleased with rig time saved and the efficient completion of a good well.

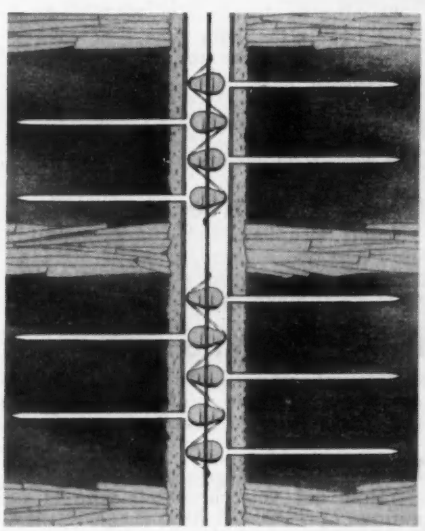
Full Volume Penetration Gained with Powerful Super Casing Glass Jets

200 Feet of Pay Zone Perforated in Two Runs for 800 Thousand Cubic Feet of Gas and 350 Barrels of Oil Per Day

A new zone discovery in an old field was perforated by powerful McCullough Super Casing Glass Jets with gratifying results.

Total depth of the well was below 11,000'. 8⅝" O.D. 36 lb. casing had been cemented in 10¾" open hole. Interval to be perforated was from 10,840' to 11,040'.

Two 100' Steel Strip Carriers were made up and loaded, 2 per foot, with McCullough Super Casing Glass Jets. After the first gun was fired the casing pressure built up to 2,000 lbs.



The Steel Strip Carrier may be loaded full length to perforate a single zone, or blank sections may be left to straddle unwanted intervals and perforate multiple pay zones in a single run.

After the second gun was fired the well flowed at 500 barrels of oil per day and surface pressure built up to 3,000 lbs. The well is now flowing through the casing at the rate of 350 barrels of oil and 800 thousand cubic feet of gas per day.

McCullough Super Casing Glass Jets are the deepest penetrating of all jet charges of a comparable size. In recent official penetration tests, witnessed by oil company engineers, they attained an average penetration of 9.208" in Berea sandstone targets. And, they are carrot-free, to boot!

McCullough Super Casing Glass Jets assure "full volume" penetration—best possible production—more oil.

The jobs described above are certified to be true field reports of services rendered.

McCullough® TOOL COMPANY

Cable Address: MACTOOL

LOS ANGELES
HOUSTON
EDMONTON

For more data on advertised products, use Readers' Service Cards, last page.

INCREASE PRODUCTION

CLEAN OUT CHOKING SAND

Excessive sand and sediment holds back your oil. For fast, easy clean out with fewer round trips and less down-time, use world famous Miller Sand Pumps.

SAND PUMP SIZES

O.D.—2½, 3, 3½, 4¼, 5, 5½, 7 In.
Lengths—20, 25, 30 ft.

Composite Catalog, Page 3419

Write for descriptive price list

MILLER SAND PUMPS

Miller Sand Pump Co.

General Offices, Box 4516
Oklahoma City 9, Okla.

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SECONDARY RECOVERY
Since 1922

PETROLEUM ENGINEERS
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Water Flooding **Gas Repressuring**
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(WORLD WIDE)

SPECTROMETRIC and CONVENTIONAL

CARAN
ENGINEERING CORPORATION

MILAM BLDG. SAN ANTONIO
Branch Offices: Houston and Alice, Texas and Lafayette, Louisiana

WORLD OIL

"Mister, how soon are ya gonna start that thing?"

moment, but the silence was soon interupted by the little girl.

"Thank you, dear Lord," she said, "for preparing a table before me in the presence of my enemies. Amen."

The Truth Is . . .

Bill: "My wife talks to herself."

Jack: "So does mine, but she doesn't know it—she thinks I listen!"

Safety's Out!

A knock came at the hotel room door.

"My husband!" exclaimed the feminine occupant. "Jump!" she told her male companion.

Dashing to the window, he looked out. "But this is the 13th floor," he said.

"This is no time to be superstitious," she replied.

Optimism

A woman on her way to a beauty parlor.

Colorful Native

Smart Alec Tourist: "What's your speed limit here?"

Native: "Ain't got none! You fellows can't go through here too fast for us."

BeBop Definition

A young cat was told to give the definition of steam. He said, "Steam is water gone crazy with the heat."

The Cure-All

"How did you cure your wife of her antique craze?"

"Oh, I just made her a birthday present of a 1923 model automobile."

To the Top

Boss to employe: "What's this I hear about you praying for a raise? You know I don't like people going over my head."

And Then the Kill

A little boy was sitting behind a bald-headed man at church, who was scratching the fringe of hair on one side of his bald pate. The old gentleman kept it up so long that at last the little boy became interested, and, leaning over, said:

"Say, mister, you'll never catch him there. Why don't you run him out in the open?"

STITT Sour Gas SPARK PLUGS

LAST 10 TIMES LONGER

Stitt "X" Type Sour Gas plugs resist corrosive action of sour gas — last months longer — require fewer changes—cut "down" time. It's not the plug price, but the "change cost" that's important! Stitts cost a little more — save hundreds of dollars per engine per year. Factory equipment in Clark, Cooper-Bessemer, Worthington, other leading engines.

Free Write for Field Test Reports
$1 Gap Gauge

STITT Ignition Company
Columbus 1, Ohio

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BELL ENGINE SERVICE	JNO. MULLER CO.
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MAGNETO IGNITION SERVICE	R. ANGUS (ALBERTA) Ltd. CAN

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SAND-BANUM

PURE COLLOIDAL CONCENTRATE

Ounces Only Once a Week Automatically Result in More Power, Less Fuel, Longer Equipment Life.

•

For ALL Radiator Cooling Systems—Stationary or Mobile

SAND-BANUM SPECIAL

IN HANDY TABLETS

Maintains the cooling system free from rust, crust, sludge, dirt, oil, grease and lime; any and all clogging matter.

Stocked by Leading Supply Houses
Gulf Coast District Representatives

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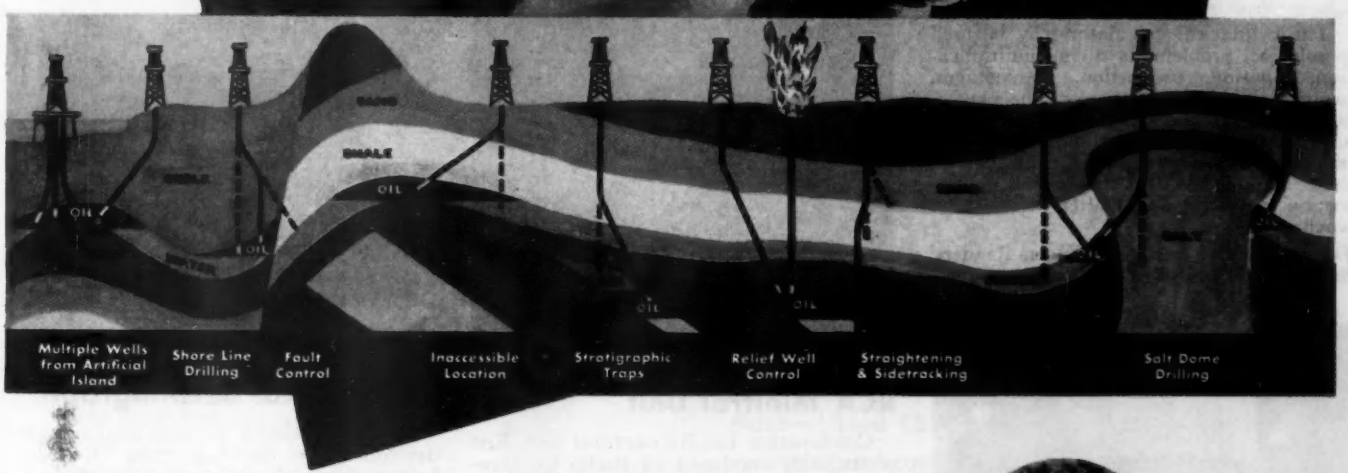
AMERICAN SAND-BANUM CO.
ESTABLISHED 1926
MEADOW BROOK NATIONAL BANK BUILDING
FREEPORT, NEW YORK

EASTMAN

THROWS A TRUE LIGHT ON SUB-SURFACE SURVEYS



The value of Eastman's contributions to oil's progress is inestimable. As *originator* of Controlled Directional Drilling . . . Sidetracking . . . and *pioneer* of oil well bore hole surveying, Eastman has dedicated 27 years to these highly specialized services. It is little wonder then that the methods, techniques, and specialized tools developed and perfected by Eastman have become the accepted standards throughout the world. That's why you can call on Eastman — any hour day or night — with full confidence that you will receive superior service and impeccable counsel.

EASTMAN

EASTMAN OIL WELL SURVEY COMPANY
LONG BEACH • DENVER • HOUSTON • CALGARY

EASTMAN INTERNATIONAL DIVISION
For Export Write
P. O. BOX 1500 DENVER 1, COLORADO, U.S.A.

DIRECTIONAL DRILLING . . . SIDETRACKING . . . OIL WELL SURVEYING

For more data on advertised products, use Readers' Service Cards, last page.

What's New In Equipment

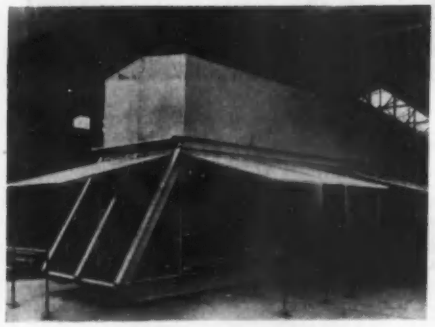
Drilling • Production • Exploration

Cylindrical Slide Rule

Arthur F. Smith Co. of Rochester, N. Y., introduces a cylindrical calculator with an accuracy greater than any slide rule currently on the market. The new calculator, by spiraling the scales around a tube instead of in a straight line, achieves graduations equal to those of a 66-inch slide rule.

The cylindrical calculator may be used to solve all problems involving multiplication, division, proportion, percentages, logarithms, roots and powers. The plastic-covered scales are fully resistant to wear and moisture, and since all parts of the instrument are made of metal throughout, there is no possibility of warping or distortion usually found after a time in wooden slide rules.

For more data, circle **No. E1** on Readers' Service Card, last page this issue.



Utility House

This power house is a Leyland-Albion Auto Diesels product, designed to meet a special requirement of oil companies. It is used during oil field exploration.

The power provided varies according to customers' wishes, but it is possible to give a maximum of 375 kVA. The utility house is an all-steel, all-welded construction, skid-mounted for portability. A removable 5000 gallon fuel tank is mounted on the roof. This fuel tank is sufficiently high to allow free gravity flow of fuel to the engines.

The house is usually divided into generator room and tool room, the switchgear being mounted in the generator room. Fully automatic shut-down equipment is incorporated in the control panel.

For more data, circle **No. E2** on Readers' Service Card, last page this issue.

Synthetic Treating Agent

Magnet Cove Barium Corporation has completed a pilot plant for experimental production of a new synthetic drilling fluid treating agent. The product is the result of two years research by a staff headed by Dr. K. P. Munroe under the general direction of Dr. W. A. Reddie, director of research. Development and plant design was handled by James W. Hayward, chemical engineer of Houston.

(This item supplements Magnet Cove Barium Corp. data on Pages 3162-3163 of the Composite Catalog, 22nd Edition.)

For more data, circle **No. E3** on Readers' Service Card, last page this issue.

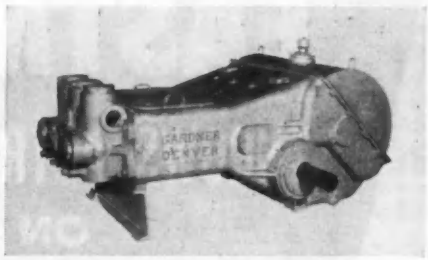
RCA Minitrol Unit

Combination talk-hear-control unit, first of its kind, developed by Radio Corporation of America, is designed to take "desk clutter" out of mobile radio base station installations. Made possible by transistors and miniaturized components, RCA unit, known as Minitrol, combines in a single compact case microphone, speaker and controls necessary for station operation of two-way radio systems. Minitrol can be pre-set for hands-free operation; and provides a foot switch for transmitter operation.

For more data, circle **No. E4** on Readers' Service Card, last page this issue.

Well Servicing Pump

A newly designed triplex plunger pump, which makes cementing, acidizing and fracturing operations more efficient and economical, is announced by Gardner-Denver Company.

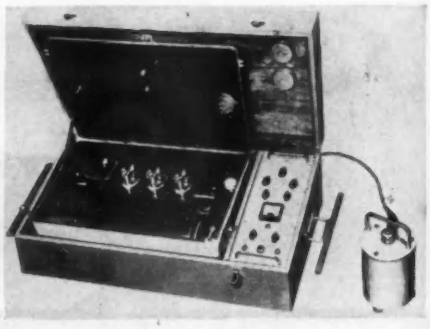


This pump is available with an underslung jackshaft, which brings the jackshaft in closer connection with the power take-off provided by the truck. As a result, power transmission is more direct and pumping operations are more efficient. It can be supplied with standard upper jackshaft construction.

The new Gardner-Denver 8-inch stroke pump is rated at 310 bhp for this service. With 4½ inch plungers, it develops 290 gpm at 1550 pounds per square inch to 56 gpm at 8000 psi. With 4-inch plungers, the capacity ranges from 228 gpm at 2000 psi to 44 gpm at 10,000 psi.

(This item supplements Gardner-Denver Co. data on Pages 1945-1964 of the Composite Catalog, 22nd Edition.)

For more data, circle **No. E5** on Readers' Service Card, last page this issue.



Geophysical Seismograph

A newly designed portable seismograph, developed by the University of Cambridge, England, and combining the rugged, compact construction of a field instrument with the delicate sensitivity of an observatory model, is now available in the U. S., it was announced by the Jarrell-Ash Co. of Newtonville, Mass.—exclusive U. S. sales & service agency.

Produced by Hilger & Watts Ltd., British instrument manufacturer, the Watts Willmore Pattern Seismograph records for up to 24 hours at 60 mm per minute, with needle-sharp definition, and is designed for a variety of geophysical applications including blast recording, rockburst studies, study of earth shocks related to volcanic activity, teleseismic work, plus other applications within the construction and petroleum industries.

The seismograph's portability and simplicity of operation make it ideal for field use. Among typical applications is the determination—at proposed construction

DMS® and DME®

Latest surfactant mud materials

give fast, trouble-free drilling

DMS & DME drilling mud additives are one of the mud industry's biggest advances in decades: a "surfactant mud" system with unique in-the-hole advantages:

1. **INHIBITS SWELLING AND DISPERSION OF CLAYS.** Shale cuttings do not disperse in the mud. Formation permeability is not reduced because formation clays do not swell.

2. **MOVES CUTTINGS OUT FASTER.** Lubricates cuttings and gets them away from the bit faster and out of the hole quicker.

3. **QUICKER SETTLING IN MUD PITS.** Drilled solids settle out faster, giving less solids build-up, easy mud control, less cost for weight materials.

4. **STABLE TO HIGH TEMPERATURES.** DMS & DME muds are stable at the highest temperatures yet encountered in drilling.

These new surfactant muds are easy to use, easy to control. They let you drill faster with less strain, and pull a clean bit from a clean hole. DMS & DME are distributed to the oil industry everywhere through Baroid Division, National Lead Company. Write direct to Baroid using convenient coupon below, for a complete 10-page technical bulletin on DMS & DME.

COMPOUND MUD WITH DMS & DME TO MEET YOUR SPECIAL NEEDS

Water-phase muds can be made easily with DMS additive and standard materials. For oil emulsion muds, add DME. Both are nonionic chemicals. Other principal mud additives generally used include a polyanionic filtration control agent and electrolyte such as calcium sulfate (for a calcium surfactant mud) or sodium chloride (for a sodium surfactant mud). Complete applications are described in DMS-DME bulletin from Baroid Division, National Lead Co.

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P. O. Box 1675, Houston 1, Texas

Gentlemen: Send me your DMS & DME bulletin.

Name_____ Title_____

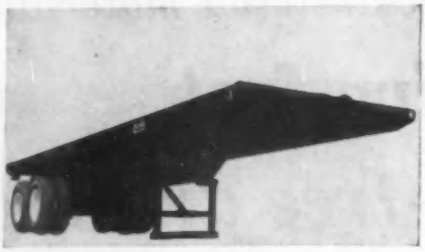
Company_____

Address_____

City_____ State_____

For more data on advertised products, use Readers' Service Cards, last page.

sites—of subterranean vibrations and stresses to which a structure or foundation may be subjected.
For more data, circle **No. E6** on Readers' Service Card, last page this issue.



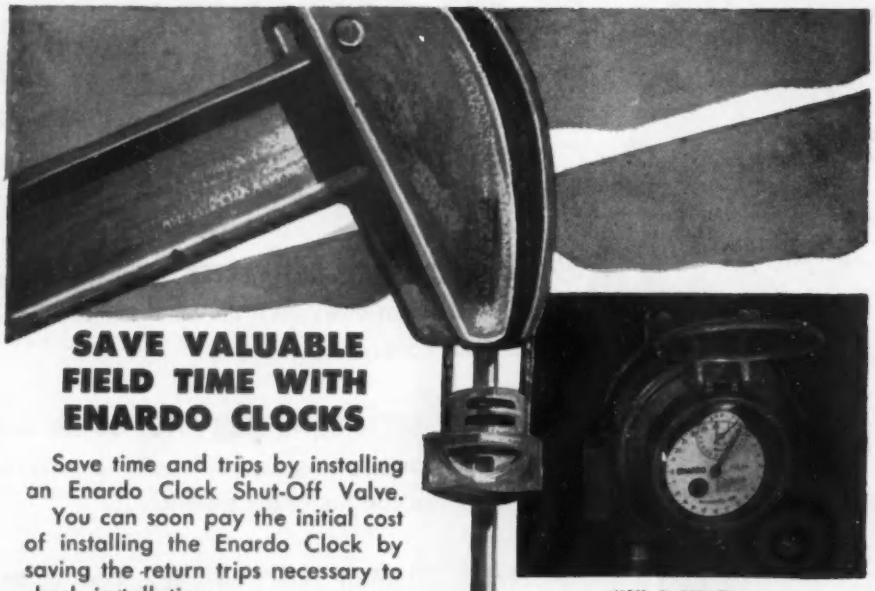
Heavy-Duty Trailer

Production of the new "808 oil field float"—a lightweight heavy-duty oil field trailer, is announced by officials of Spencer-Safford Loadcraft, Inc., Augusta, Kansas. The new heavy-duty oil field trailer weighs less than conventional trailers, yet is rated for as much as five tons more payload.

The favorable weight-strength ratio has been achieved through the use of special formula 808 steel with a 9-inch outer rail and a frame fully 18 inches deep. The new Spencer-Safford trailer weighs 9600 pounds—more than a ton less than conventional makes.

(This item supplements Spencer-Safford Loadcraft Inc. data on Pages 4864-4865 of the Composite Catalog, 22nd Edition.)

For more data, circle **No. E7** on Readers' Service Card, last page this issue.



SAVE VALUABLE FIELD TIME WITH ENARDO CLOCKS

Save time and trips by installing an Enardo Clock Shut-Off Valve.

You can soon pay the initial cost of installing the Enardo Clock by saving the return trips necessary to check installations.

The Model "W" Clock is designed to control the flow of low pressure gas or liquid and to shut off the supply at a predetermined time, with a positive bottle tight seal. Valve will function at operating pressures up to 100 p.s.i.

The Enardo "MB" and "A" time cycle switches are designed to control electrical circuits on pumping engines and other equipment. They will shut-down the engine at any number of hours, up to 22 hrs. on the 24 hr. model; and 11 hrs. on the 12 hr. model. All clocks are manually wound and set.

Always look to Enardo for the finest in oil field equipment.

"A" & MB Type Time Cycle Switch

"W" Clock Shut-Off Valve

ENARDO manufacturing co.
BOX 1647 • TULSA, OKLAHOMA

Oil Prospector

A Walking Magnetometer for oil and mineral prospecting is announced by the Radiac Co., Inc. It is used to measure the vertical component of the earth's magnetic field for the solution of a wide variety of geophysical exploration problems.

Used like a Scintillometer or Geiger Counter, the Walking Magnetometer locates and delineates sub-surface magnetic minerals directly such as magnetite and pyrrhotite and locates minerals of varying magnetic character and oil-bearing structures indirectly. Magnetometer anomaly studies may indicate and permit mapping of placer deposits, buried contacts between two materials of appreciably different magnetic susceptibilities, ridges, faults, salt domes and other oil structures etc. The Walking Magnetometer can be used to locate and trace magnetic and non-magnetic ore formations in the absence of rock outcroppings and can be operated over areas covered with muskeg, snow and water, where the conventional magnetometer cannot be used with ease. It also can be operated from a non-magnetic boat for prospecting the bottoms of small and large bodies of water.

For more data, circle **No. E8** on Readers' Service Card, last page this issue.

Nondestructive Equipment

A portable unit, the KRH-3D, provides an effective source of current for inspecting welds for lack of penetration and fusion, slag inclusions, crater cracks, thermal cracks both in weld and parent metal, porosity and gas pockets, and other defects. These units furnish both half-wave direct current for locating sub-surface defects, and alternating current for the most

effective means of finding cracks open to the surface.

The YM-5 and Y-5 yoke kits are low cost kits containing all materials necessary for finding cracks open to the surface. Yoke, Magnaflux powder, and two applicator bulbs are supplied in convenient metal carrying case. Compact design permits one man to perform complete inspection. The Y-5 operates on 115 volt, a.c.; the YM-5 from a permanent magnet. A new, sensitive spray-on fluorescent penetrant method, the ZA-43 Zyglo test kit is also a new kit. This kit shows cracks, pores, porosity and leaks as glowing lines or dots under black light. It is manufactured by the Magnaflux Corp.

(This item supplements Magnaflux Corp. data on Page 3161 of the Composite Catalog, 22nd Edition.)

For more data, circle **No. E9** on Readers' Service Card, last page this issue.

Universal Potentiometer

The Allegany Instrument Company, Inc., Model P-55 is a small, lightweight potentiometer and millivolt source in one instrument. It measures 4⅛ inches by 4½ inches by 7½ inches and weighs only 3½ pounds. Designed for precisely the conditions encountered in the field and in the laboratory, the P-55 can be used with any thermocouple, or to measure any potential in the 0 to 55 mv. range.

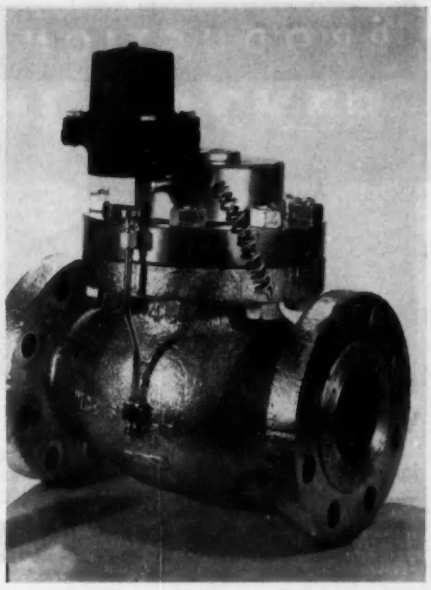
In addition, the instrument will accurately supply the same millivolt potential for check-out of recorders and other instruments. The P-55's dual input provides two sets of 55-way binding posts for convenience in checking two thermocouples, or one thermocouple against a standard etc. A thermometer is shock-mounted in the lid, and the instrument is available in a weather-proof aluminum case or durable mahogany.

For more data, circle **No. E10** on Readers' Service Card, last page this issue.

Steel Solenoid Valves

A new line of cast steel solenoid valves for liquids to 600 pounds per square inch is now available in sizes 2-inch, 2½-inch, 3-inch and 4-inch. They can be either globe or angle pattern with screwed or flanged pipe ends.

Features include renewable seat rings, unbreakable piston rings and packless operation over a wide pressure range. The valves are designed to eliminate damaging hammer and shock in automatic or remote control.



Coils are unconditionally guaranteed. Greenclad, waterproof molded coils for temperatures to 250° F. and silicone insulated coils for higher temperatures. Coils are interchangeable between sizes and with all other Gould valves.

The valve illustrated is a 3-inch Type EO-2 Gould solenoid valve, 300# ASA flanged. It is equipped with explosion-proof coil housing. It is available from J. D. Gould Company.

For more data, circle **No. E11** on Readers' Service Card, last page this issue.

OTIS
FLOW LINE
SAFETY VALVES

Night-and-Day Protection
for High-Pressure Wells

OTIS/Branches Throughout the Oil Country

PRESSURE CONTROL · OTIS · SERVICE - EQUIPMENT

PRODUCTION

Valve Tool

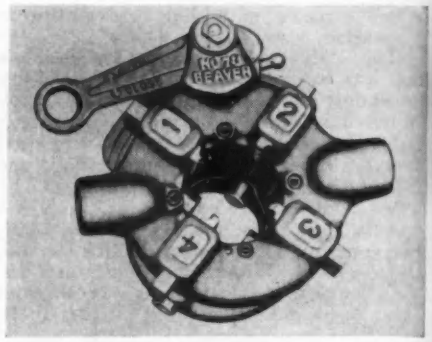
A new valve tool, for quick, convenient installation and removal of all rubber snap-in valves, has just been announced by the Dill Manufacturing Company, Cleveland, Ohio.

The tool is designed to accommodate all size valves for either 14-inch or 15-inch wheels, in any size rim. It easily installs valves by applying pulling pressure and, with only a slightly additional pressure, will remove a valve by pulling it completely through the hole.

For more data, circle **No. E12** on Readers' Service Card, last page this issue.

Quick-Opening Threader

Threading dies, 1⅛-inch wide—the same width as the standard length for a 1, 1¼, 1½, or 2-inch thread—are an exclusive feature in the No. 78 Beaver quick-opening power drive threader manufactured by Beaver Pipe Tools, Inc., of Warren, Ohio. The Beaver No. 78 threader threads all sizes 1-inch to 2-inch with one set of high-speed steel dies—no die changing. Being the same width as the standard length thread, the dies give a perfect taper for the entire length of the thread.



The Beaver No. 78 threader is made specifically for power drive use, and the manufacturer claims it to give faster operation with more threads in less time than ordinary threaders. There is no lead screw to wind and unwind. This tool cannot jam. When the thread is cut, the dies are thrown open and the tool is ready to use again without resetting. The original setting remains accurate. A new rear guide gives perfect thread alignment. There is nothing to clamp on the pipe.

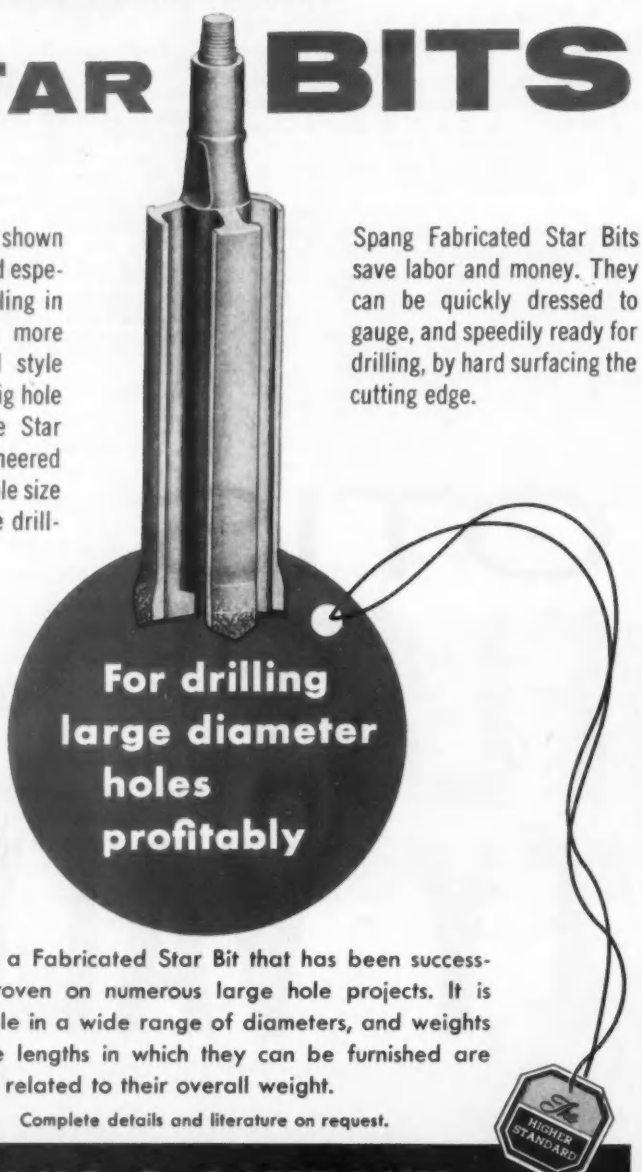
(This item supplements Beaver Pipe Tools, Inc., data on Page 653 of the Composite Catalog, 22nd Edition.)

For more data, circle **No. E13** on Readers' Service Card, last page this issue.

FABRICATED STAR BITS

The Fabricated Star Bit shown here has been designed especially for big hole drilling in hard formations. Far more efficient than the old style spudding bit and the big hole paddle-type bit, these Star Bits are custom-engineered to suit the particular hole size and the capacity of the drilling machine used.

Spang Fabricated Star Bits save labor and money. They can be quickly dressed to gauge, and speedily ready for drilling, by hard surfacing the cutting edge.



For drilling large diameter holes profitably

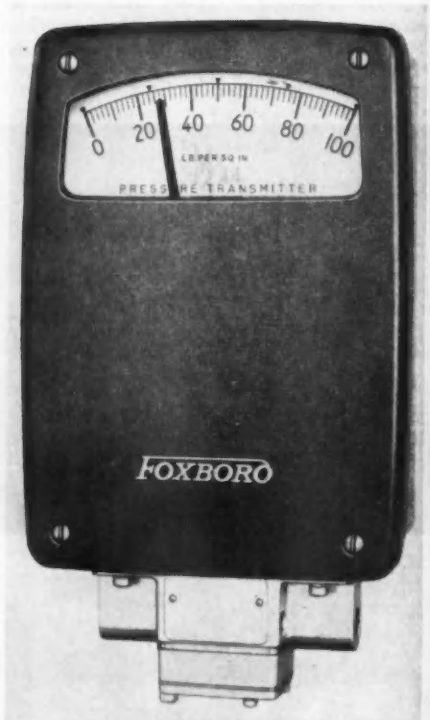
Here is a Fabricated Star Bit that has been successfully proven on numerous large hole projects. It is available in a wide range of diameters, and weights . . . the lengths in which they can be furnished are directly related to their overall weight.

Complete details and literature on request.

SPANG & COMPANY

DEPT. O-6 BUTLER, PENNSYLVANIA

For over 60 years Manufacturers of Spang Weldless Jars and a Complete Line of Cable System Drilling and Fishing Tools for Oil and Gas Wells, Prospect Drilling and Shot Blast Holes.

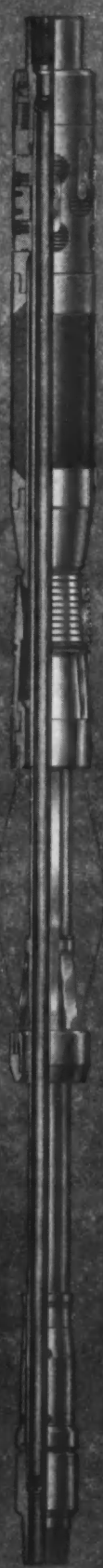


Pressure Transmitter

A new, inexpensive indicating pressure transmitter, accurate to ±½ percent of scale range, has been announced by The Foxboro Company, Foxboro, Mass., for pneumatic transmission of process pressure measurements. Known as the Model 44 pressure transmitter, it measures pressures of 0-30 inches of water to 0-6000 psi, transmitting a 3-15 pounds per square inch air signal to indicating, recording or controlling instruments.

To accommodate the various ranges, a choice of standard Foxboro pressure ele-

THE BROWN BOLL WEEVIL PACKER



RUGGED... DEPENDABLE

Here is a packer that is really made to do a tough job. Its sturdy, rugged design incorporates features that make this a highly desirable packer to use.

Rugged features—check 'em!

1. Built-in hydraulic hold-down — actuated by pressure *below* the packer. The hold-down slips are not exposed to fluids and solids in the tubing.
2. Built-in safety — if necessary, the stem may be unlatched from the packer providing a short stroke jar and a by-pass for circulation. Stem automatically relatches when setting back down.
3. Built-in strength — a tough compression type seal holds against the highest pressures. It can be set and reset numerous times with assurance that it *will hold.*
4. "Boll Weevil" setting and releasing features. Just pick up the tubing and set it down. No rotation or other tricky manipulation to set or pull the packer.
5. Full-opening, too!

Dependable applications—check 'em!

For high pressures of squeeze cementing, fracturing, acidizing and testing.

For selective treating, the "Boll Weevil" is ideal as top packer in a two packer hook-up. "Straddle" jobs are simplified with the unbeatable combination of the *Boll Weevil* and the *Brown BP-4* Bridging Plug Packer. Work easily above or below either packer, run them together, pull them together or leave them as production packers.

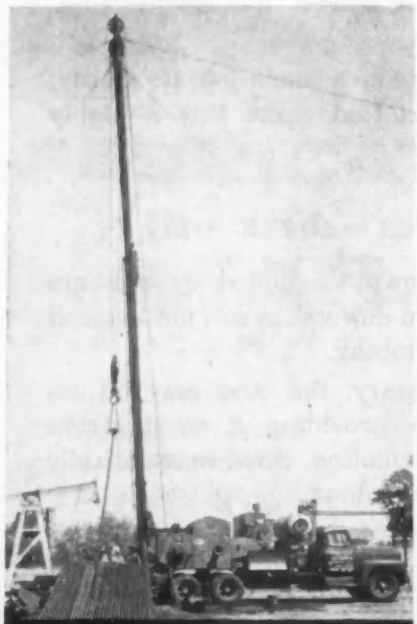
For any production job you have. It's especially suited to deep, crooked or deviated, high pressure wells.

BROWN
OIL TOOLS, INC.

8490 KATY ROAD
HOUSTON, TEXAS

Designed to

REDUCE COSTS



WICHTEX

Well Servicing Units

Any Wichtex owner will tell you that Wichtex units cost less to operate and maintain, and are unequalled for long life without overhaul. Wichtex units combine the outstanding efficiency, economy, and mobility which enable you to do a fast, dependable job at minimum cost.

Write for catalog. Eight models range from 2,000′ to 12,000′ capacity. All models can be equipped with spudding attachment.

Also investigate Wichtex Rotary Rigs for 2,000′ to 5,000′ drilling.

WICHTEX MACHINERY COMPANY INC.
WICHITA FALLS TEXAS
Box 2250 Ph. 2-8612

ments is offered—spirals, helicals, bellows and diaphragms; element materials are available for corrosive process fluids.

Eliminating the need for a separate field gage, the transmitter has an eccentric indicating scale, 4⅛-inch long, built into the front of the case. Red pointer and black-on-white scale markings are visible from as far away as 20 feet to provide indication at point of measurement.

(This item supplements The Foxboro Co. data on Pages 1782-1785 of the Composite Catalog, 22nd Edition.)

For more data, circle **No. E14** on Readers' Service Card, last page this issue.

Shielded Hanger Mill

A new tool for milling hangers inside casing at extremely high speeds and milling up fish without damaging the casing is now available from Servco, Long Beach, Calif.

The high milling speeds possible with the new Servco shielded liner hanger mill result from the use of Servcoloy, a new cutting material.

Although designed primarily for milling hangers inside casing, the new Servco shielded liner hanger mill is also useful for any type of milling inside the casing, particularly in milling fish where the O.D. of the fish is large enough that most conventional mills would damage the casing. Where the fish has split or flared, the new mill pushes it to the I.D., allowing the inner blades of the tool to contact and mill the fish.

(This item supplements The Servco Co. data on Pages 4679-4720 of the Composite Catalog, 22nd Edition.)

For more data, circle **No. E15** on Readers' Service Card, last page this issue.

Telescoping Derrick

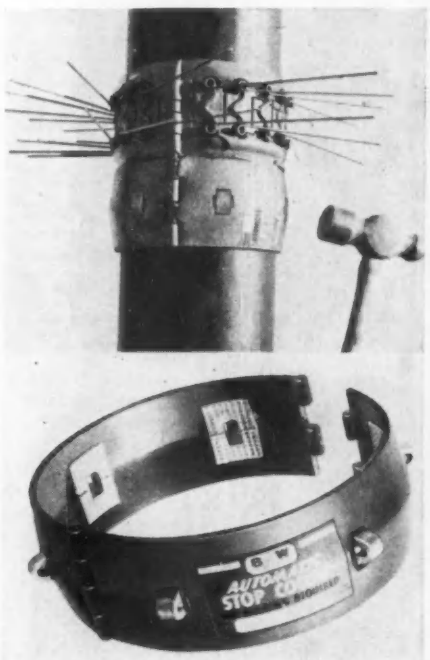
This telescoping derrick and its accessory well-servicing equipment are virtually all-aluminum. Weighing about one-third less than an all-steel unit of similar capacity, it offers a solution to the problem of transporting such equipment over public highways.

The portable unit, manufactured by the Franks Division of Cabot Shops, Inc., Tulsa, features not only an all aluminum derrick but also an aluminum bed, winch frame, guards, cab, wheels and truck bogie. It was developed by Franks engineers working in conjunction with Reynolds Metals Company, supplier of the aluminum.

The total height of the derrick assembly is 68 feet; the folded length is 42 feet 4 inches. The unit's operating live capacity is 100,000 pounds.

(This item supplements Cabot Shops, Inc., data on Pages 1109-1115 and 1877-1928 of the Composite Catalog, 22nd Edition.)

For more data, circle **No. E16** on Readers' Service Card, last page this issue.



Automatic Stop Collar

B and W automatic stop collars permit the mounting of scratchers and centralizers on higher carbon and other alloy casing, where welding is not considered safe practice. They are positioned on the casing joint as desired, and the slips are permanently set by hitting downward on the outer loop with a heavy peen hammer until the loop is flush with the casing. The collars have an interior concave form with opposed expanding slips which are attached to the outer loops, and the slips securely wedge the collar on the casing.

The device is supplied in solid collar form or hinged for installation on external upset casing. The simple installation meets the requirements of oversize and undersize A.P.I. casing, casing reciprocation or rotation and has maximum resistance to movement on the casing.

Easy and dependable installations remove the hazard of field welding on the higher grades of oil field casing.

(This item supplements B and W Incorporated data on Pages 381-388 of the Composite Catalog, 22nd Edition.)

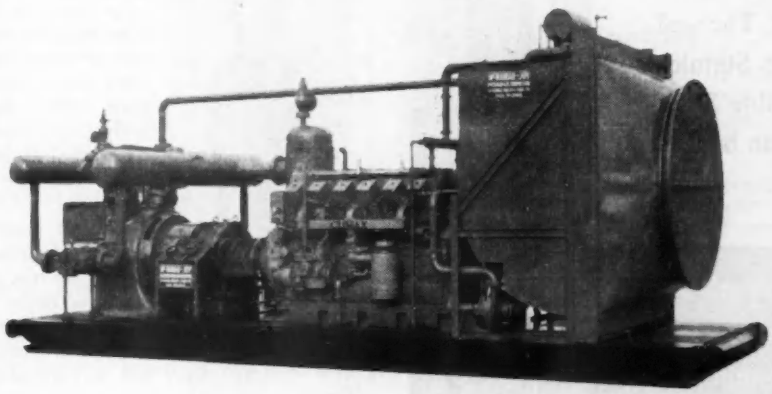
For more data, circle **No. E17** on Readers' Service Card, last page this issue.

McNAMAR – JOY

GAS COMPRESSORS

This unit, packaged by McNamar Boiler and Tank Company, is operating in California, boosting gas from 100 psig suction to 400 psig discharge. Capacity 4.5 MMCFD.

The cooler, fabricated by McNamar, cools the engine and compressor jacket water and after cools the gas to 130°. The unit, mounted on a skid 8 ft. wide x 32 ft. long, weighs 45,000#. Only the suction and discharge connections are necessary to place into service upon delivery.



- **VERSATILE**
- **COMPACT**
- **PORTABLE**

Find out how McNamar-Joy Gas Compressors can be engineered to your gas boosting needs. Units are available in 50, 100, 200 and 400 horsepower. Send this coupon today and McNamar will mail to you bulletins with complete technical details — also information regarding purchase, rental or rental-purchase options.

McNamar Boiler and Tank Company
P. O. Box 868
Tulsa 1, Oklahoma

Please send bulletins on McNamar-Joy Gas Compressors.

Name_____

Title_____

Company_____

City_____ Zone____

State_____

McNAMAR TULSA

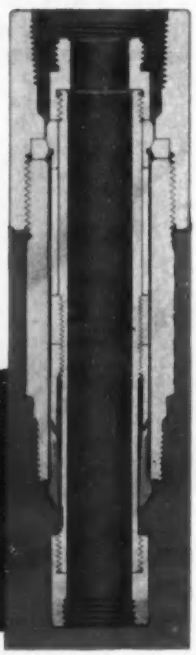
McNAMAR BOILER & TANK CO.

BOX 868 — TULSA, OKLAHOMA CHerry 2-6291

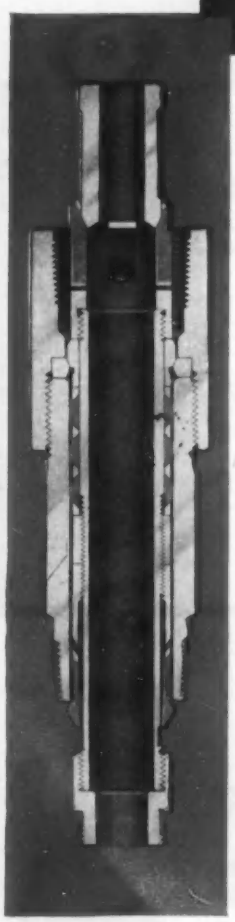
Wireline servicing made easy with a

PACIFIC PERMANENT COMPLETION PUMP HOLD DOWN

The Pacific Permanent Completion Hold-Down is designed with maximum opening through the shoe to permit use of Permanent Completion Tools through it. The sealing arrangement has replaceable Stainless Steel Sealing Ring with a reversible Stainless Steel Sealing Ring Seat and can be used on any type A.P.I. rod pump.



Undersize rings can also be furnished to allow pumps to be run through a Permanent Completion "S" Nipple and seated in the pump shoe.



If at any time the Stainless Sealing Ring Seat, which is part of the Tubing Assembly, should become damaged or leak, an effective seal can be obtained without pulling tubing. The Rod Assembly is engineered and designed so that by replacing the Spacer Ring on the Hold-Down Lock Body with three Ring Type Seating Cups, the seal is transferred to the Seat Support Nipple with the Sealing Ring and Sealing Ring Seat serving as a No-Go ring and supporting the load.

PACIFIC PUMPS, INC.

HUNTINGTON PARK, CALIFORNIA

Offices in all Principal Cities

Mid-Continent Division: 1221 E. 1st St., Tulsa, Oklahoma

Pacific Pumps of Canada, Ltd., Edmonton, Alberta

PACIFIC®

DW-17

DRILLING

Hard Shale Bits

The Servco shale bits recently developed by Servco, were developed to fill the gap between rock bit and diamond drilling. They are especially economical when drilling hard, rubber-like shale.

The new bits consist of three components, with the core breaker used inside the bit head. This feature is unusually advantageous in side tracking operations. The bit does not have the tendency to drop back on the cement plug when used on whipstock runs. The core breaker and core head can be easily replaced.

Bits of carbide are suspended in a tough, elastic matrix so that hundreds of carbide cutting edges are always in contact with the surface to be cut. As particles are worn or torn away, new cutting edges are automatically exposed.

(This item supplements The Servco Co. data on Pages 4697-4720 of the Composite Catalog, 22nd Edition.)

For more data, circle **No. E18** on Readers' Service Card, last page this issue.

Electronic Road Map

An "electronic road map" navigational system has been successfully adapted to enable a helicopter pilot operating in offshore oil areas to take off, fly to any spot inside a 100-mile area, and land safely without looking outside the helicopter cabin.

The "self contained instrument landing system" was revealed in a three-day series of demonstration flights as a joint operation of Bendix Aviation Corporation's Pacific Division and Bell Helicopter Corporation. The demonstrations, at Bell's plant near Fort Worth, culminated a year-long research project undertaken to make it possible to operate helicopters in remote areas at night or in weather requiring instrument flight.

In existing helicopter operations such as offshore oil rig shuttle services, the Bendix and Bell engineers said the immediate application of the system could mean increasing the percentage of flight completions to nearly 100 percent.

The blind-flight helicopter system combines a Bendix-Decca navigator, Bendix Sonic altimeter, an improved attitude display and a glide path indicator.

For more data, circle **No. E19** on Readers' Service Card, last page this issue.

New Equipment Catalogs and Literature

For more data on New Equipment or copies of Catalogs and Literature reviewed in this issue, use the Reader's Service postcards just inside the back cover and facing the Advertisers Index. Simply circle code numbers of items desired—sign and mail card. Requests are transmitted to the manufacturer as soon as received by us for mailing of desired information directly to you.

Oil Field Engine Booklet

Horsepower rating data on Allis-Chalmers oil field engines is now available in a new four-page bulletin BU 165. The data covers 16 natural gas powered models; 15 powered by either butane or propane gas; 17 diesel engines, and 14 engines powered with gasoline.

In addition to listing the number of cylinders, piston displacement, bore and stroke and maximum torque at various revolutions per minute of each engine, information also includes the horsepower of each model at various operating speeds. Suggested method of determining usable horsepower ratings for various oil field services is outlined.

To get a copy, circle **No. E20** on Readers' Service Card, last page this issue.

Rotary Rig Pamphlet

Extreme portability and speed of the Model 35 rotary drill rig are explained in a new bulletin issued by Joy Manufacturing Company. The bulletin features field photographs and complete specifications illustrating the flexibility of the Joy "Thirty-Five" as a geophysical shot hole or shallow water well rig.

To get a copy, circle **No. E21** on Readers' Service Card, last page this issue.

Float Valve Catalog

A new 16-page technical bulletin explaining the features of Golden-Anderson cushioned float valves has just been published by Golden-Anderson Valve Specialty Co.

G-A cushioned float valves maintain accurate water level control in elevated tanks, reservoirs, coagulating basins, mixing chambers etc. They are designed for either cold or hot water service in either the quick opening or throttling design with integral or remote pilot control.

To get a copy, circle **No. E22** on Readers' Service Card, last page this issue.

Reciprocating Pump Sheet

Data Sheet 100, which contains complete information on Aldrich 25-horsepower to 2400-hp direct flow pumps, is available from The Aldrich Pump Co.

This four-page, two color brochure features Aldrich triplex (3 plunger), quintuplex (5 plunger), septuplex (7 plunger), and nonuplex (9 plunger) reciprocating pumps. It also describes and illustrates the Aldrich-Groff Power-Savr pump's stepless, straight-line control of capacity—from zero to rated output without any change in speed of power source.

In addition to design and material specifications, this condensed catalog also presents dimension tables and a pump selection chart for the complete Aldrich line. It is designed as a quick reference source for engineers, production and management personnel.

To get a copy, circle **No. E23** on Readers' Service Card, last page this issue.

AAODC Fact Booklet

Basic facts about the oilwell drilling contracting industry are reviewed in a new 12-page, pocket-size booklet published by the American Association of Oilwell Drilling Contractors.

Designed to acquaint engineering students and newcomers to the industry with the drilling business, the booklet contains a brief review of the economics and tools of drilling, and a commentary on the men in the industry and the services they perform.

To get a copy, circle **No. E24** on Readers' Service Card, last page this issue.

Gas Lift Technical Manual

The Guiberson Corporation, one of the Dresser Industries, announces publication of a 36-page gas lift technical manual. The manual covers the latest available information on gas lift theory and practice, detailed installation procedures, formulas, charts, tables, and appropriate illustrations. Written from a technical rather than sales standpoint, this manual was prepared as a general reference book to aid in the designing of gas lift installations. Unique to this publication are valve spacing charts, for continuous flow installations, covering four ranges of flowing gradients.

To get a copy, circle **No. E25** on Readers' Service Card, last page this issue.

Rockwell Catalog

A completely revised condensed 28-page catalog (C-5000, Rev. 8) covering Rockwell meters, regulators and valves has been introduced by Rockwell Manufacturing Company.

Outstanding new features of the catalog include photo-illustrated descriptions of the recently introduced Rockwell telapilot—with power pilot loading by remote control—and the Hypregun, a light compact, efficient air-operating valve lubricant gun. The catalog also includes completely revised Nordstrom valve specifications and is completely restyled throughout, with new emphasis on the use of photo illustrations of all major products described.

To get a copy, circle **No. E26** on Readers' Service Card, last page this issue.

Venturi Valve Data

Catalog sheet illustrates and gives specifications and prices of Orbit Valve Company's new 2-inch by 1-inch Venturi type production valve with screw ends. Advantages of Orbit's new screw end, forged steel, stainless trim Venturi type valve include savings in cost, reduced weight and operating torque.

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Portable Hoist Catalog

A new 12-page, 2-color booklet No. 3-45C describes Joy single drum multi-purpose portable hoists has been published by the Joy Manufacturing Company.

The well-illustrated booklet carries descriptions and specifications for the Joy line of air, electric and gasoline driven models.

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